OCTOBER 1961
Vol. 80, No. 10

ELECTRICAL ENGINEERING

Published by American Institute of Electrical Engineers

CONTENTS

Electrical Features of the Niagara Power Project T. E. THORGERSEN, J. BASILESCO 739
This 2.19-million-kw project will be the largest hydro installation in the Western Hemisphere, if not in the world

Cable Engineering: A Multidiscipline Technology L. F. HICKERNELL 745
Nearly all branches of engineering and science are involved in the design, manufacture, and operation of electric cables

The Feasibility of Superconducting Power Transformers RICHARD McFEE 754
Design details for a 3-phase superconducting transformer show the practicality of these small-loss devices

Electrical Techniques and the Heart in Health and Disease G. G. KNICKERBOCKER, W. B. KOUWENHOVEN 761
A discussion of electrical measuring techniques in basic physiology, diagnosis of disease, and treatment of disease

Large-Scale On-Line Data Processing Systems S. LEVINE 767
These systems are finding increasing use in such fields as transportation, banking, and inventory control

Monitoring Density of Artificial Atmospheres in Hermetically Sealed Equipment B. A. HICKS 772
A means has been developed for monitoring leakage by sensing molecular density instead of pressure

Standardization: A Stated Objective of the Institute C. G. VEINOTT 775
The AIEE Standards Committee chairman believes that turning over standards making to the ASA would be detrimental

Photoelectric Controls for Street Lights E. KEITH HOWELL 780
Analysis of natural light at dusk and dawn and criteria for control of street lights photoelectrically to best advantage

Strength and Related Properties of Wood Poles G. Q. LUMSDEN 786
A review of the long-awaited final report of the ASTM Wood Pole Research Program

DEPARTMENTS

Trends . . . as seen by EE 788

Progress in Technology 789
Fast System Links Computer Centers 789
Fastest Digital Computer Ever Built 790
Thermoelectric Devices Show Unique Designs 791
Space Topics in the News 792
Arctic Weather Research 793
Medical Conference News from the Waldorf 794
Digital Computer Directs Dispatching Control System 795

CONTENTS CONTINUED ON PAGE 3A

Charles S. Rich
Editor and Manager of Publications

G. C. Baxter Rowe
Ronald K. Jurgen
Associate Editors

Samuel Walters
Robert E. Whitlock
Technical Editors

Gladys Charitz
Eleanor F. Peck
Assistant Editors

Carol A. James
Editorial Assistant

Ruth M. Edmiston
Art Director

ADVERTISING
J. S. Lopes
Middle Atlantic Manager
345 E. 47 St.
New York 17, N. Y.
PLaza 2-6800

J. S. Holzer
Eastern Manager
345 E. 47 St.
New York 17, N. Y.
PLaza 2-6800

E. R. Bollinger
Central Manager
P.O. Box 506
West Richfield, Ohio
OLiver 9-4800

A. E. Del Gado
Mid-West Manager
1604 Chicago Ave.
Evanston, Ill.
GReenleaf 5-1132

T. P. Galavan
A. C. Dillenbeck, Jr.
Western Adv. Office
266 South Alexandria Ave.
Los Angeles 4, Calif.
DUnkirk 5-3991
333 Kearny St., Rm. 310
San Francisco 8, Calif.
EXbrook 2-4073

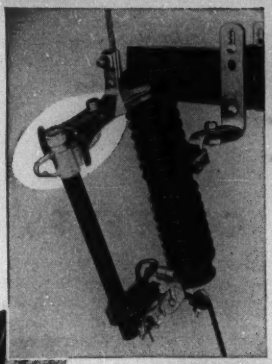
B. C. Nichols
European Office
151 Fleet St.
London E.C. 4, England

Waldo Schraubstader
Market Research Director

Frances Newman
Advertising Production Manager

"FOLLOW-ACTION" CONTACTS OF KEARNEY "GX" CUTOUTS

...eliminate danger of external arcing
...prevent recoil damage



KEARNEY

"FOLLOW-ACTION"

LOCKS CONTACTS CLOSED UNTIL FAULT IS INTERRUPTED

Stainless steel springs in the top contact assembly of the Kearney GX cutout, absorb shock... and by "following" any motion of the cartridge created by recoil impact, keep the top contacts firmly locked together under high pressure until the fault has been interrupted. Contacts cannot separate during interruption to cause external arcing or contact burning.

Ball and socket contacts are self-aligning, cannot be bent or twisted out of alignment by severe faults, and always seat properly regardless of the angle of cartridge close-in. Dependable, safe operation is assured.

Balanced Double Venting... prevents recoil damage. Expendable cap blows on high faults. Expulsion gases discharge from **both** ends of the GX cartridge to equalize pressure and neutralize recoil shock. At the same time, relief of excess pressure within the cartridge prevents tube bursting. On low amp faults, the GX cartridge single-vents from the bottom only, assuring ample gas pressure for positive interruption.

Cast Bronze Hood... prolongs cutout and contact life by protecting top "follow-action" contacts from severe weather and ice. Hood also shields contacts from dirt and corrosive elements, providing added insurance of dependability and long life. Extra-wide entry jaws guide cartridge securely into contacts even at awkward close-in angles.

Contact your Kearney Sales Representative or write for Bulletin 1A.

KEARNEY

for better construction... safer maintenance... specify KEARNEY products

JAMES R. KEARNEY CORPORATION

4224-42 Clayton Avenue • St. Louis 10, Missouri

512

PLANTS AT: ST. LOUIS • MELROSE PARK, ILLINOIS • FAYETTEVILLE, ARKANSAS • GUELPH, ONTARIO, CANADA • ST. THERESE, QUEBEC, CANADA

OCTOBER 1961
Vol. 80, No. 10

ELECTRICAL ENGINEERING

Published by American Institute of Electrical Engineers

CONTENTS (continued)

New Library Books	796
Technical Literature	798
Russian Translations	800
AIEE on the Move	803
56 Technical Sessions for Fall General Meeting	803
Nomination of AIEE Officers Begins	807
Group Relationship Among ITGs, Sections and TDGs	808
Pacific Meeting Report	809
Electrical Engineering Exposition	810
Calendar of Future Meetings	811
Biomedical Engineering Conference Scheduled	812
Student Prize Papers Winners Announced	812
Educational Publications Committee Promotes Material	813
Future Meetings of Other Societies	814
Organizing the Engineering Profession to Achieve Unity	814
29th Annual Meeting of ECPD to Take Place October 2-3	816
Members in the News	818
Obituaries	821
Summaries of AIEE Papers	822
New/Improved Products	8A
Product Literature	26A
Industrial Notes	36A
Engineering Societies Personnel Service, Inc.	38A
Index to Advertisers	44A

ABC
Member
Audit Bureau of Circulations

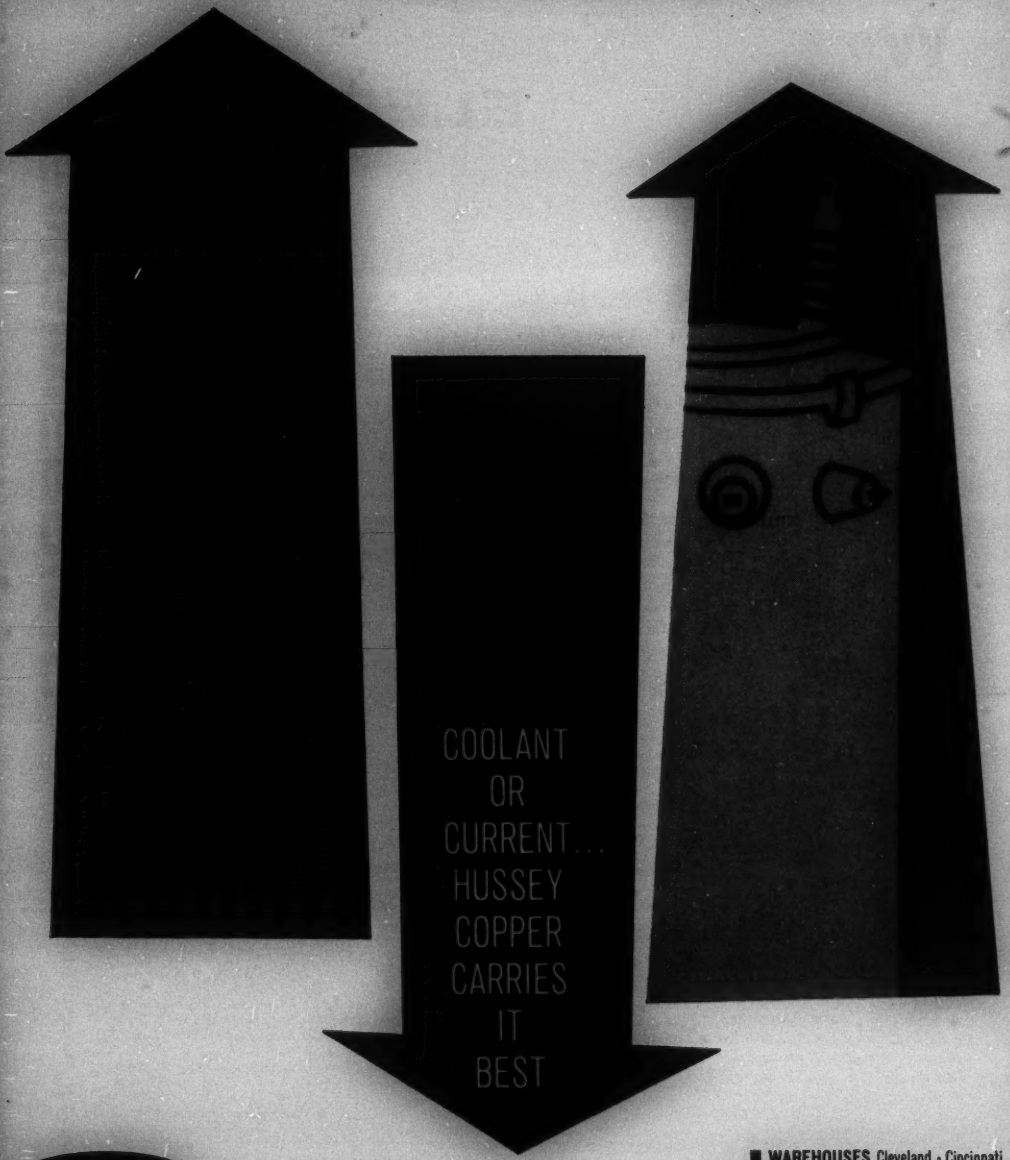
THE COVER
Workmen are shown using thin wooden shims to protect stator windings as 595-ton rotor is lowered into place for Unit No. 1 at the Niagara Generating Plant. Story on p. 739

Number of copies of this issue, 70,000.
PUBLISHED MONTHLY by the American Institute of Electrical Engineers, 345 East 47 St., New York 17, N. Y. Printed in the United States of America by Hildreth Press, Bristol, Conn. Editorial and advertising offices, 345 East 47 St., New York 17, N. Y.
Copyright 1961 by the American Institute of Electrical Engineers.
MEMBER SUBSCRIPTION $6 per year nondeductible from dues; single copy 75 cents. NONMEMBER SUBSCRIPTION $12 per year plus extra postage to all countries to which second-class postage rate does not apply; single copy $1.50.
Entered as second-class matter at the Post Office, Bristol, Conn., under the act of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925.
ADDRESS CHANGES must be received at AIEE headquarters by the first of the month to be effective with the succeeding issue. Copies undelivered because of incorrect address cannot be replaced without charge. Indexed annually by the AIEE, weekly and annually by *Engineering Index*, and monthly by *Industrial Arts Index*; abstracted monthly by *Science Abstracts* (London).
Statements and opinions given in articles appearing in *Electrical Engineering* are expressions of contributors for which the Institute assumes no responsibility. Correspondence is invited on controversial matters.

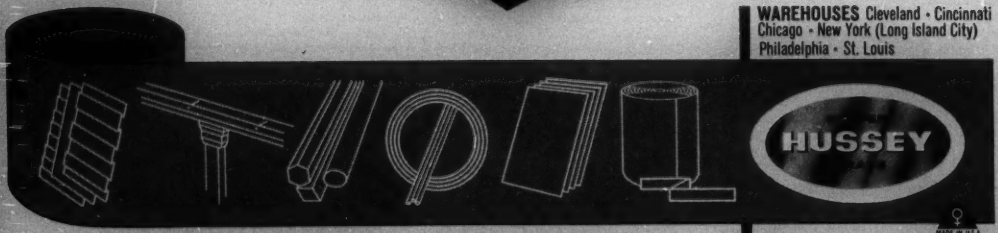
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

W. H. CHASE, **President** N. S. HIBSHMAN, **Executive Secretary**

PUBLICATIONS DEPARTMENT: W. F. Denkhaus, Director; H. N. Muller, Jr., Vice-Chairman; C. S. Rich, Staff Secretary; T. H. Cline, Charles Concordia, H. E. Corey, Jr., G. W. Dunlap, R. A. Ellison, Burke Frick, Lenine Gonsalves, E. T. B. Gross, D. L. Hemmenway, J. Paul Jordan, C. P. Knost, F. L. Lawton, C. W. Leihy, L. F. Lewis, M. S. Merritt, F. W. Norris, P. R. Sprowl, J. D. Tebo, J. J. Tesar, P. G. Wallace, B. James Wilson.



WAREHOUSES Cleveland • Cincinnati
Chicago • New York (Long Island City)
Philadelphia • St. Louis

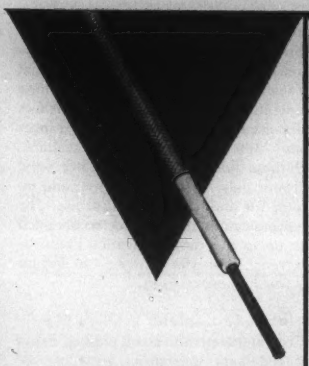


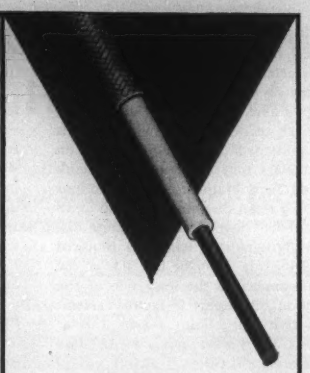
C. G. HUSSEY & COMPANY ▪ PITTSBURGH 19, PA.

DIVISION OF
COPPER RANGE COMPANY

MADE IN U.S.A.
TO THE STANDARDS
OF AMERICAN INDUSTRY

Wire & Cable Selector





APPARATUS and MOTOR LEAD WIRE	LIGHTING WIRE
600 volt	600 volt
200°C	125°C
#20 to 4/0 AWG	#14 to #8 AWG
Conductor — Tinned copper, stranded **Insulation** — Silicone rubber **Covering** — Glass braid	**Conductor** — Solid tinned copper **Insulation** — Silicone rubber **Covering** — Glass braid
For leads to motors and transformers in high temperature locations. Stands up excellently under varnish dip and bake processes.	For lighting circuits in high ambient temperature locations.

Rockbestos Silicone rubber cables give you these outstanding advantages:

- excellent heat resistance 125°C-200°C allowable conductor temperature
- flame resistant—slowly forms non-conducting ash maintaining circuit integrity
- corona and ozone resistant
- maintains flexibility from —130°F to +500°F
- excellent resistance to oil, solvents, fuels and chemicals
- excellent electrical properties

ROCKBESTOS WIRE AND CABLE CO.
division of CERRO CORPORATION
Nicoll and Canner Sts., New Haven, Conn.

Gentlemen:

I would like to know more about the unique advantages of Rockbestos Silicone Rubber Wire and Cable. Please send me the following:

- ☐ The Rockbestos Silicone Wire & Cable Catalog.
- ☐ A sample of your silicone rubber wire.
- ☐ Please have distributor or salesman call.

Name_____

Company_____

Address_____

NEW/IMPROVED PRODUCTS

A-C Gear Motors . . .

Gear motors of the hysteresis synchronous and low-slip induction fractional-hp type have been marketed. The former overcomes the objectional condition present in conventional induction motors where speed can fluctuate as the result of sudden variations in line voltage or in

load. The low-slip induction gear motor was designed to fulfill the needs of applications requiring high starting torque and excellent full-load efficiency. Both types can be supplied to custom requirements, with a torque range up to 300 ounce-inches at 1 rpm in the induction type. *Ashland Electric Products, Inc., Dept. EEN, 32-02 Queens Blvd., Long Island City 1, N. Y.*

Ten-Point Monitor . . .

Accurate, sensitive, low-cost monitoring of from one to ten points is possible with a new electronic economy monitor. Typical applications for the device include monitoring temperature, pressure, speed, pH, flow, or other variables. Each point to be monitored is scanned in sequence and its value compared to a preestablished set point. Scanning speeds are available from 1 to 10 seconds per point to suit customers' requirements. Calibration accuracy is 0.25 per cent of full-scale span. Sensitivity is 1 microvolt, independent of scale span. *Thermo Electric Co., Inc., Saddle Brook, N. J.*

Plastic Pipe . . .

Developed for use underground or encased in cement, a new line of plastic electric conduit weighs one sixth as much as steel and can be installed in one third the time required for metal conduit. The new conduit is said to be free from corrosion, rust, or the effects of electrolysis. It is nonconducting and nonmagnetic. The pipe is extruded in 10-foot lengths with one end coupled. Each length is dated, tested, and its test history noted for reference by customers. *Lasco Industries, Montebello, Calif.*

Metering Switchboard . . .

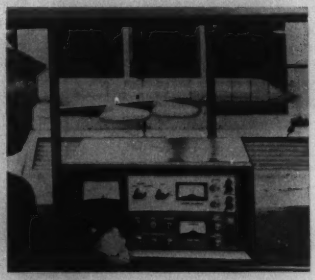
A new free-standing metering switchboard accommodates nearly twice as many meters in half the space required for comparable quantity of wall-mounted units. Each section of the switchboard is a self-contained free-standing unit on which meters may be mounted on both front and back. Main or primary sections comprise a main disconnect and up to 18 each of meter bases and distribution disconnect. No interior wiring is required since all bussing from the line side of the main disconnect to the load side of the distribution disconnect is factory assembled within the unit. *I-T-E Circuit Breaker Co., Walker Div., P. O. Box 2384, Atlanta 18, Ga.*

Wire Markers . . .

Each self-adhering marker in this new line is partly a write-on marker and partly transparent as a self-contained lamination extension. When applying a marker around wire, the remaining protective clear portion wraps around itself causing it to laminate permanently over the written code. Free working samples from a variety of stock sizes are available. *Westline E-Z Code Div., Western Lithograph Co., 689 E. 2nd St., Los Angeles 54, Calif.*

Dynamic Analyzer . . .

Vibration and waveform analysis becomes relatively simple with a new dynamic analyzer now available. The device shown in use for wind tunnel flutter testing of a Convair 990 jet airliner, is an inherently frequency-tuned band-pass filter. The center frequency of the filter pass band is positioned automatically and



continuously by an external frequency such as that provided by a tachometer or oscillator. The unit has a flat response, within 1 db, from 50 to 2,500 cps. Any conventional transducer may be used. *General Dynamics/Electronics, Information Technology Div., P. O. Box 2449, San Diego 12, Calif.*

Temperature Controllers . . .

Front-panel control setting and an easy-to-read, servo-controlled indicating dial are features of a new series of indicating temperature controllers. The 6000-A series accommodates temperature ranges from −300 to +2,000 F. It is available with three indicator types: indicator only; indicator only for multipoint use; and indicator for multichannel control use. The servo indication system may be obtained with up to five remote location controls. *Electronic Processing Corp., 436 Bryant St., San Francisco, Calif.*

Portable Radiometer . . .

Critical temperatures of plastics being extruded, paper or fabrics being coated, calender rolls, and inaccessible or moving surfaces can be sensed without touching by means of a new portable, battery-powered pyrometer. The instrument detects overheated electrical units, bear-

ings, or pipes and is sensitive to 0.1 C. Operational control models are also available. *Williamson Development Co., Inc., 317 Main St., W. Concord, Mass.*

Subway-Type Oil Switch . . .

Able to withstand momentary and short-time currents to 25,000 amperes, a new watertight subway-type 3-pole M-35 switch has porcelain insulators, laminated copper brushes, and stud and contact blocks. The switch is designed for disconnect service on underground distribution systems. *Allis-Chalmers Mfg. Co., Industries Group, Milwaukee 1, Wis.*

Synchronous Motor . . .

An a-c timing motor with no slippage, ability to stop without coasting, and to be instantaneously reversed without recourse to mechanical no-back devices has been introduced. The new 46100 series

(Continued on page 20A)

T. E. THORGERSON and J. BASILESCO

Electrical features of THE NIAGARA POWER PROJECT

The 2.19-million-kw Niagara Power Project, now well on its way to completion, will be the largest hydroelectric installation in the Western Hemisphere, if not in the world. The salient electrical design features of the project are described.

The Niagara Power Project consists, electrically, of three major parts: the Robert Moses Niagara Power Plant, the Lewiston Pumping and Generating Plant, and the Niagara High Voltage Switchyard. All are located in the town of Lewiston, N. Y., a short distance north of Niagara University. The project is being built by the Power Authority of the State of New York; the engineering, design, and construction supervision of the project are being carried out by Uhl, Hall & Rich, of Boston, Mass.

The Moses power plant is located on the Niagara River on the American side about 3 miles below the Falls, directly opposite the Hydro-Electric Power Commission of Ontario's Sir Adam Beck II Station. The plant, having a gross available head of 314 feet, consists of an intake structure located at the lower terminus of the surge basin on the Lewiston plateau, concrete-encased welded plate steel penstocks, and a reinforced-concrete powerhouse located at the bottom of the Lewiston escarpment.

The Lewiston plant is located on the plateau at the upper terminus of the surge basin, with the switchyard situated on the same plateau about midway between the two plants. An intake structure has been built on the Niagara River at a point approximately 3 miles above the Falls, and two water conduits, 66 feet high by 46 feet wide about 4 miles long, have been constructed to carry the water from the intake structure to the surge basin.

The Niagara River, which runs out of Lake Erie into Lake Ontario, has an annual flow of about 203,000 cfs (cubic feet per second). To maintain the scenic beauty of the Niagara Falls, an international agreement between the United States and Canada requires that at least 50,000 cfs of water must pass over the Falls at all times, and in the tourist period from April to November 1, the daytime flow must be held to a minimum of 100,000 cfs. The remainder of the water is available for power generation and other purposes. Half of this remaining water is used by Canada, leaving a minimum of some 50,000 cfs available for power generation on the United States side in the summer months. During the times when only 50,000 cfs are required to flow over the Falls, some 74,000 cfs will be available to each country for power generation.

The estimated cost of this project is about $720 million, financed entirely by the sale of bonds. The first unit went into commercial operation at the end of January 1961, about 2 weeks ahead of scheduled time, and all construction work is to be completed by December 1962.

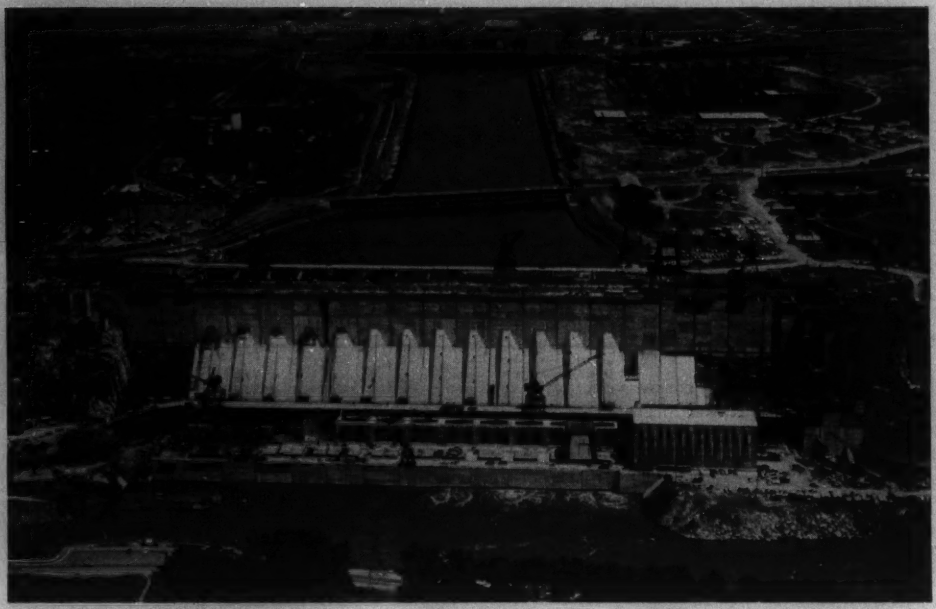
The Niagara Falls district is highly industrialized, with a vast network of transmission lines. Before any major construction work could get under way, approximately 40 miles of transmission and distribution lines of all voltages from 5 to 230 kv had to be relocated out of the construction area at a cost of about $10 million. An enormous amount of underground electrical and other utilities and a number

Courtesy Power Authority, State of New York

Artist's conception of completed reservoir pump-generating plant and transition area covered conduit to open power canal. View is to south

A condensation of two conference papers presented at the AIEE Summer General Meeting, Ithaca, N. Y., June 18-23, 1961. Recommended for publication by the AIEE Power Generation Committee.

T. E. Thorgerson, Member AIEE, and J. Basilesco, Associate Member AIEE, are with Chas. T. Main, Inc., Boston, Mass.



Courtesy Power Authority, State of New York

General aerial view, looking east, showing main generating plant, (foreground) and Lewiston pump generating plant (background) linked by open canal (center). Niagara switchyard is at right center

of houses also had to be relocated before the construction work could proceed.

ROBERT MOSES PLANT

The Moses power plant is the main generating station, and the powerhouse is a modified outdoor type in which elimination of the conventional superstructure affords substantial economy.

Turbines

This plant will house 13 vertical hydraulic turbines of the Francis type, and all units will be installed progressively in one single stage of construction. Each turbine has a capacity of 200,000 hp at a point of best efficiency, will operate at 120 rpm, and will have a runaway speed of 208 rpm, under a net head of 300 feet.

Generators

The generators have a name-plate rating of 167,000 kva at 0.9 power factor and will operate at 120 rpm, 13.8 kv, 3-phase, 60 cycles. They are of the vertical-shaft umbrella type with a combined guide and thrust bearing below the rotor and no upper guide bearing. High-pressure oil lubrication is provided on the thrust bearings for use when the units are started and stopped. These units have a totally enclosed ventilating system and are provided with automatic CO_2 fire protection.

Main Power Transformers

The design of the Moses plant was based on a straight unit system, wherein each generator is connected to its own 180,000-kva step-up transformer with no 13.8-kv generator breaker provided.

Each generator is connected to its main step-up transformer by means of a set of 8,000-ampere isolated phase leads. Taps are provided from the isolated phase leads to a generator surge protection cubicle and a 300-kva unit station service transformer.

The 2-winding delta-Y-connected 3-phase 60-cycle step-up transformers are forced oil–forced water cooled. The transformers connected to the seven generators occupying the south half of the Moses plant structure will step up the voltage to 120 kv, and the remaining six to 240 kv. The basic insulation level for the 120-kv transformers was reduced one full step from 550 to 450 kv, and the BIL (basic impulse insulation level) of the 240-kv transformers was reduced a step and a half to 825 kv.

LEWISTON PUMP GENERATING PLANT

The Lewiston pump generating plant has been designed as a peaking plant, the generator–motors of which are run as synchronous motors for pumping whenever excess water is available and as long as storage capacity permits. These units, when used for pumping, will pump the excess water some 66 to

106 feet up into the 60,000-acre-foot reservoir with a drawdown of some 35 feet. Whenever the stored water is needed for extra power it will be released to operate the hydraulic machines as turbines to drive the electric units as generators, which then will rotate in a direction opposite to that of pumping. This would cause phase reversal at the generator terminals, necessitating a phase-rotation reversing switch, motor operated for remote control, in the generator–motor leads. Any water discharged through the Lewiston plant into the surge basin will also flow through the Moses power plant, thus increasing the over-all plant capacity by some five times the amount generated by the Lewiston Plant, without increasing the river drainage.

Since, by international agreement, a certain minimum flow must be maintained over the Falls, a very close check on the water used by the plant is imperative at all times. For this purpose an electronic computer will be installed in the main control room. The computer will take into account the following data:

1. The river water level at the project intake, the water level of the Moses tail race, the surge canal level near the Moses intake, and the pumped storage reservoir level.
2. The rate of flow allowable for generation as received from a joint water dispatch center at hourly intervals or longer.
3. The total power output of the Niagara Project received continuously from the watt-hour meters.

On the basis of this information, the computer would then determine the most efficient number of units required at Lewiston either for pumping or generating. The computer would also generally determine the number of units required to generate at Moses for most efficient operation.

The power for pumping would nearly always be available from the Moses power plant, but could be obtained from nearby thermal plants if conditions should warrant this.

Pump–Turbines

The Lewiston pump generating plant has 12 vertical hydraulic pump–turbines of the modified Francis type.

Generator–Motors

The generator–motors, when operating as generators, will have a name-plate rating of 25,000 kva, 0.8 power factor, 13.8 kv, 3-phase, 60 cycles, and will operate at 112.5 rpm. When operating as motors, they will have a rating of 37,500 hp, 1.0 power factor, 13.2 kv, 3-phase, 60 cycles. They are designed for starting as induction motors at full voltage, with a starting current guaranteed not to exceed 3½ times that of full load.

The generator–motors also are of the vertical-shaft umbrella type, with combined thrust and guide bearing below the rotor and no upper guide bearing. High-pressure oil lubrication will also be applied on the thrust bearings of these machines during starting and stopping.

Main Power Transformers

At the Lewiston pump generating plant, there is one power transformer for each group of three generator–motors. Each transformer has a rating of 100 mva, 240-13.2 kv, 3-phase, 60 cycles, 2-winding, forced oil–forced water cooled, with a BIL of 825 kv.

With more than one unit connected to a transformer, 13.8-kv generator breakers are necessary, and indoor air circuit breakers of 1,500,000-kva interrupting capacity have been procured for this service.

High-Voltage Circuits

Elimination of the overhead transmission lines between the power plants and the switchyard was made possible by the installation of underground cables in tunnels, using high-pressure-oil pipe-type cable. Seven 115-kv and six 230-kv circuits, one circuit for each unit transformer, each circuit with a capacity of 200 mva, connect the Moses power plant with the switchyard. Four 100-mva 230-kv circuits connect the four Lewiston plant transformers with the switchyard. The use of high-voltage-cable circuits from the powerhouse to the switchyard makes the four breakers per switchyard bay feasible, rendering both ends of the bay available for outgoing transmission lines.

Courtesy Power Authority, State of New York

595-ton rotor for Niagara Power Project generator is suspended from crane

Station Service

The station service substations for the auxiliaries directly connected with the operation of the units at the Moses power plant are each supplied from a 300-kva, 13.8-kv to 480-volt dry-type transformer connected to the generator leads through a disconnecting switch without a circuit breaker on the 13.8-kv side.

At the Lewiston plant, unit auxiliary power is supplied from four 500-kva, 13.8-kv to 480-volt transformers connected directly to the generator paralleling buses. Thus, each service transformer will serve three generator–motors.

Station service power for auxiliaries common to the whole project such as cranes, station heating, switchyard service and lighting, etc., are supplied from transformers which are energized from the 13.8-kv tertiary windings of two 200-mva bus-tie autotransformers in the switchyard. A feeder cable from each of these tertiary windings feeds its own section of the 13.8-kv service switchgear in the switchyard service building. The bus-sectionalizing circuit breaker of this switchgear is normally open, but is arranged to close automatically whenever one bus section goes dead. This switchgear also provides stand-by power for any one of the unit service stations, which, on loss of its own supply, will be automatically relayed to the stand-by source. This source of station service power is also used for initial starting of the units.

NIAGARA SWITCHYARD

The Niagara switchyard consists of two double-bus sections in the 115-kv part of the switchyard and one double-bus section in the 230-kv part. The two autotransformers serve to connect one 230-kv bus to each 115-kv section of switchyard.

The two forced oil–forced air cooled autotransformers are rated 200 mva, 240-120-13.8 kv, 3-phase, 60 cycles, and provide for interchange of power between the 115- and 230-kv systems. The tertiary of each autotransformer is rated for an external power take-off of 28,300 kva.

The switchyard is located in an area of very high air contamination. Power companies and industrial plants in this area have frequently experienced flashovers in the fall after an extremely dry period followed by fog. There have been cases where entire substations have been forced to shut down to permit the cleaning or replacement of insulators.

Provisions have been made for the sectionalizing of the 115- and 230-kv switchyard to permit deenergizing of a bus section for cleaning. With all circuit breakers in working order, one bus may be deenergized without jeopardizing either generation or transmission facilities, when cleaning or treating becomes necessary. Interruptions in service will be partly overcome by overinsulation. Additional creepage has been provided on all outdoor bushings, potheads, and insulator stacks to avoid shutdowns caused by insulator flashovers.

A 20,000-kva substation, consisting of two 10,000-kva, 115- to 138-kv transformers and switchgear built by the Power Authority to provide the necessary construction power for the project, is located at the project site near the Stauffer Chemical Plant. After a study of the contamination effects on insulators and equipment and experiments with various surface applications on the porcelain of this substation, silicon grease was chosen for this purpose on all porcelain in the switchyard. The grease was applied by a method of spraying. It is too early to say how long the first treatment will be effective, but at present a very marked decrease in corona on the treated as compared to nontreated porcelain in the same area can be observed.

The Niagara switchyard forms a strong link in an already vast power concentration, firmly connected as it is to the Niagara Mohawk, Rochester Gas and Electric, New York State Electric and Gas, and Ontario Hydro Power systems. Early studies indicated that power circuit breakers of the interrupting capacity utilized at the Robert Moses power dam (on the St. Lawrence River) would not safely meet the interrupting requirements at Niagara.

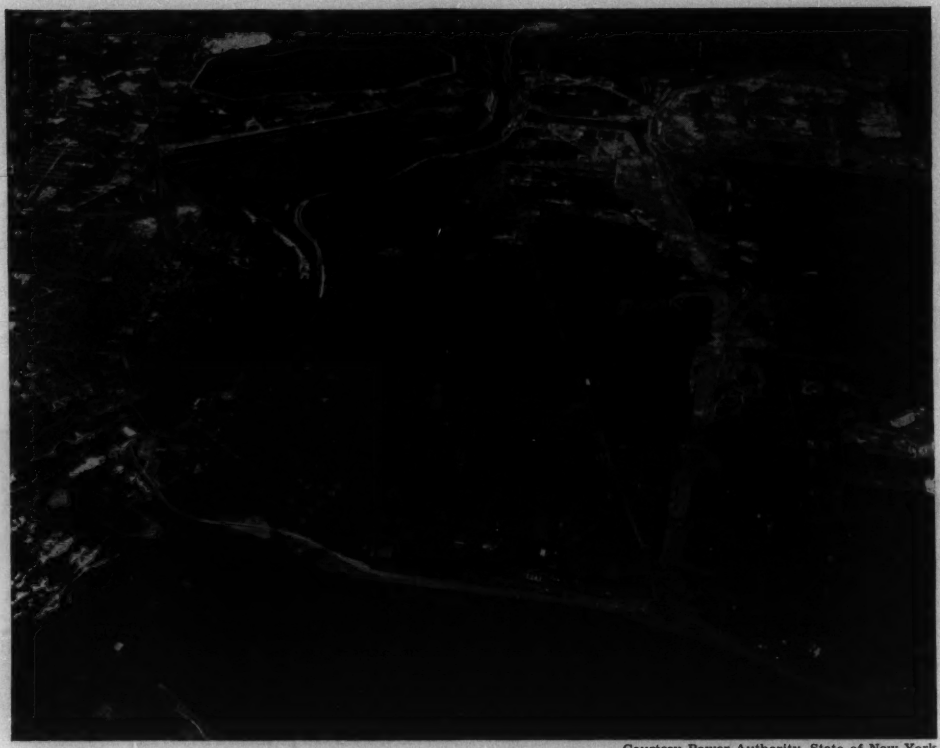
American manufacturers connected with the St. Lawrence Project were co-operative in furnishing 115-kv circuit breakers of 10,000,000-kva interrupting capacity. The 15,000-mva breakers needed for Niagara meant a completely new design which might require at least 2 years to engineer and build. Because of the accelerated program which had been adopted for this project, time was not available for the development of such a breaker. Thus, it was necessary to sectionalize the 115-kv buses at the New York State Power Authority's Niagara project, as well as the Packard station of the Niagara Mohawk Power Corporation, in order to reduce the available short-circuit current.

The American manufacturers agreed to furnish 230-kv breakers with an interrupting rating of 20,000 mva, sufficient to interrupt any presently anticipated fault currents at this voltage. Since American manufacturers were not yet ready to supply air-blast breakers to meet the design requirements, and foreign manufacturers were not able to meet the proposed construction schedule, proposals were invited on the basis of oil circuit breakers for both the 115- and 230-kv systems.

The 345-kv section of the switchyard at present utilizes two 400-mva 3-phase autotransformers, with space allowed for a third one. These autotransformers are fed from the 230-kv bus. Four 345-kv circuit breakers are at present installed in the Niagara switchyard. Because little or no actual operating experience had yet been gathered with an air-blast breaker of a domestic design, oil-type circuit breakers were finally chosen for this voltage as well.

Station Control

The main control room is located at the south end of the Moses power plant. All units in the two power stations as well as all high- and medium-voltage circuit breakers in the switchyard are controlled from this room. A combination duplex board, with a bench section for the controls and upright panels for the in-



Courtesy Power Authority, State of New York

Aerial view looking northwest from 22,000 feet, showing entire project area from upper Niagara River (foreground) to Lewiston Village (center background)

struments and relays, is provided for this purpose. A separate duplex upright board, also located in the main control room, contains all the recording instruments, such as the water flow and megawatt recorders. A duplex tunnel-type switchboard is located in the switchyard service building and carries all protective relays for the autotransformers, the high-voltage buses, and the transmission lines. All of the transmission line watt-hour meters are also located on this board.

Each generator at Moses power plant can be started in automatic sequence from a master switch in the main control room. The operation of the master control switch will energize the master contactor, which in turn will start the various unit auxiliaries and initiate turbine gate opening in proper sequence. Automatic synchronizing equipment is also available to the main control room operator at his discretion.

The operator may select the method of starting as well as synchronizing. On manual control, the Moses units, together with their auxiliaries, will be started and brought up to approximately synchronous speed at the unit control boards located on the operating gallery near each unit. From this point, the main control room operator will take over and put the unit on the line either by automatic or manual synchronizing as desired.

The Lewiston pump generating plant is equipped for remote operation from the Moses control room by means of supervisory control over pilot wires. An operator at Moses will be able to select the generating or pumping mode of operation, start and stop each unit, and adjust the loading of the units to meet the required operating conditions.

Local control, either by manual or automatic means, is also available at the plant; the automatic feature is used mainly to facilitate testing of the automatic control scheme. The local controls are at the individual unit control boards near the units.

A unique feature of the Lewiston generator–motor control is the method of putting the unit on the line as a generator. The unit is brought up to speed by turbine action as usual, under the control of the governor, but without excitation. When synchronous speed has been reached, the generator breaker and the field breaker will close and the machine will pull into step. With this method of starting, no automatic

synchronizing equipment is required. However, manual synchronizing equipment is provided on each unit control board for use whenever the units are started by manual control.

For starting a unit as a pump, the amortisseur windings of the generator–motor rotors are so designed as to give the machine the necessary torque to start as induction motors with full line voltage applied. Before the unit is started, the water in the scroll case will be depressed by compressed air to clear the runner for minimum drag while the wicket gates stay closed. The main control room operator will then initiate starting by pushing the proper button on the supervisory control panel. As soon as all the auxiliaries are functioning properly, the main breaker will close and bring the unit up to induction motor full speed in 20 seconds or less. The field application relay should then allow the generator field breaker to close at the most favorable moment for pulling the unit into synchronism.

To initiate pumping as smoothly as possible, the pump will be primed by shutting off the make-up air, and an air escape valve from the scroll case will be opened before the gates are opened. It is anticipated that the pumping cycle will start with approximately full gate opening at minimum water level in the reservoir and that the operator may decrease the gate opening from time to time by the gate limit control as the water rises.

Generator Grounding

Each Moses generator is high-impedance grounded through a 100-kva 13,800- to 240-volt single-phase transformer with a suitable load resistor in its secondary winding, limiting the generator ground current at full voltage to about 11.7 amperes. Since this ground fault current is too small for the generator differential relays to sense, a voltage relay is connected across the grounding-transformer secondary winding. This relay will operate on a very low 60-cycle voltage, but is rather insensitive to third-harmonic voltages and is wired to shut the unit down on a ground fault.

Each generator–motor neutral is grounded through a 50-kva 13,800- to 240-volt single-phase transformer. A resistor across the secondary of this transformer will allow a ground current through the generator neutral of about 5.75 amperes on a solid ground fault at normal voltage. Each generator will have a tuned voltage relay connected across its grounding transformer secondary which will be wired to trip the generator breaker and to shut down the unit. Since each of the ground relays on a group of three units will sense a ground fault on any one of the three machines equally, the relays are set to trip at different times. For any ground fault located on the generator side of the breaker, this arrangement should enable the operator to determine which one of the three machines had the fault.

D-C Control Power

Five control batteries are provided for the Niagara Power Project, each with its own motor–generator charging set. The two 60-cell batteries in each of the two power plants provide 125-volt nominal voltage, whereas the one in the switchyard is of the 120-cell 250-volt type. The high control voltage in the switch yard was chosen because of the high breaker tripping current and the long distances to the most remote breakers. All control impulses to the switchyard from the main control room will be initiated by 125 volts d-c through interposing relays located in the relay room of the switchyard building. The batteries also provide the necessary power for emergency lighting and other very important services.

Lighting

The outstanding illumination features of this project are the control room and switchyard lighting installations. The main control room will have fluorescent lamps above a plastic prismatic lens ceiling covering an area of approximately 5,400 square feet.

A mercury-vapor lighting installation utilizing the high distribution voltage of 277/480 volts was selected for lighting the switchyard. All outdoor lighting will be controlled either automatically by photoelectric switches or manually by the control room operator.

Transmission

Negotiations and allocation of the 2,190,000 kw of Niagara power are now completed. The transmission of this amount of power to local and remote load centers requires extensive facilities, which are being constructed partly by the Power Authority of the State of New York and partly by interested utilities.

The Niagara switchyard will be connected to the Niagara Mohawk system by eleven 115-kv and two 230-kv circuits. One 230-kv circuit out of the switchyard connects to the New York Electric and Gas System at Gardenville.

A 230-kv tie between the Niagara switchyard and the Sir Adam Beck II switchyard of the Hydro-Electric Power Commission of Ontario is now nearing completion.

One 345-kv transmission circuit is in operation and another is under construction from Niagara switchyard to Rochester, N. Y. From there a single-circuit 345-kv line extends to Utica, with a tap at Syracuse.

Capacity

The capacity of the Moses power plant, when completed, will be about 2,700,000 hp or 1,950,000 kw. The Lewiston plant, when generating, will provide some additional 330,000 hp or 240,000 kw. The total capacity of the Niagara Power Project, therefore, will be about 3,030,000 hp or 2,190,000 kw, making it the largest hydroelectric installation in the Western Hemisphere, if not in the world.

L. F. HICKERNELL

CABLE ENGINEERING
. . . a multidiscipline technology

Nearly all branches of engineering and science are to some degree involved in the design, manufacture, installation, and operation of electric conductors. Some highlights in the development of electric cables are recounted.

Cable engineering,* though a distinct and highly specialized field, is an integration of many disciplines. The earliest predecessors of today's cable engineers were a small group of men: inventors, experimenters, machinists. They learned about electrical science through their own experience and that of others.

The modern cable engineer must be able to design special constructions to conform to space or weight requirements; to carry varying amounts of current; to perform in trying environments. Conductors may be simple or inordinately complex, and range in size from smaller than a human hair to larger than a man's arm. They may transmit a heartbeat or 750,000 kw of power; ring a doorbell or control a nuclear reactor.

Nearly all branches of science and engineering are to some degree involved in the design, manufacture, installation, and operation of electric conductors. Among the less obvious contributors are bacteriology, entomology, mammalogy, and mycology, which aid in the war against the natural enemies of cable. Meteorology, oceanography, and geodesy provide information pertinent to cable application.

The following recounting of some highlights in electric cable development will show that every challenge has been met, is being met, and can be met in the future. It will also illustrate that in this branch of electrical engineering the interdependence of various technologies is recognized and compatibility is achieved.

An article based on the theme of an addresss presented at the Corporation Dinner, University Club, New York, N.Y., June 13, 1961, preceding conferral of the degree of doctor of engineering, *honoris causa*, by Polytechnic Institute of Brooklyn at its 106th Commencement held at Brooklyn Academy of Music, June 14, 1961.

L. F. Hickernell, past president AIEE, is vice president–engineering, Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y.

*The term "cable engineering" is used herein to designate the research, development, design, manufacture, and application of electric conductors as practiced by a manufacturer. It does not include application, installation, and operation performed by users, which is excellently covered in the Underground Systems Reference Book, published by Edison Electric Institute, New York, N. Y.

METALLURGY

Metallurgy is a fundamental component of cable engineering. Its role comprises testing, treating, improving, alloying, and finding new applications for existing metals. Orginally, it was called upon to provide a suitable conductor and protection for the insulation.

Conductors

Table 1 shows chronologically the introduction of materials to use as overhead-line conductors. The first major improvement was made by a machinist and amateur telegrapher named T. B. Doolittle. For a private telephone system, he devised so simple a process for manufacturing hard-drawn copper wire it was not even patented; yet this development made long-distance telephony possible.[4]

Sheaths

Lead was used for protection of the first underground insulated conductors in the 1830's; it and its alloys are still the predominate cable sheathing. Table 2 lists successive sheath developments.

Tin- and antimony-lead alloys assure longer life for aerial telephone cable. They were developed to resist ring-cutting and vibration fatigue.

Arsenical-lead alloy, used for power cable, has three times the life of copper-bearing lead under bending stress as well as a lower creep rate, which permits operation at higher internal pressure.[9]

Aluminum sheathing is applied by direct extrusion[10] or by drawing down an oversized tube.[11] For flexibility, it is corrugated, indented, or ribbed.

Alpeth and Stalpeth sheathings[12] for telephone cable were developed to meet the vast postwar expansion which threatened the lead supply.

CHEMISTRY AND PHYSICS

Electrical insulation is now a discipline per se. Two annual conferences are devoted to its theory, research and application. "Insulation" is both the theme and the title of a monthly trade magazine. T. D. Calli-

Table 1 · OVERHEAD-LINE CONDUCTOR MATERIALS

Year	Material	Properties and/or Initial Use
1840	Soft copper wire	Tensile strength inadequate for 200-foot spans
1846	Iron strand	Susceptibility to atmospheric corrosion
1847	Galvanized iron wire	Baltimore–Harrisburg telegraph line
1860	Copper-ribbon-clad iron	Susceptibility to electrolytic corrosion
1860	Copper alloys	Silicon-copper, phosphor-bronze tried; use discontinued in 1877
1877	Hard-drawn copper wire	Conductivity high; tensile strength adequate; New York–Boston telephone line in 1884
1883	Copper-plated steel wire	Plating thickness uncontrollable
1897	Aluminum wire	Chicago stockyards, 1/2-mile telephone line
1898	Aluminum cable	California, 46-mile power line
1910	Aluminum conductor, steel reinforced (ACSR)[1]	North Carolina, 17-mile power line
1915	Copper-covered steel (Copperweld)[2]	Molecular union effected between copper and steel
1939	Copper-clad steel (Copperply)	Plating thickness control effected; Michigan, 4-mile power line in 1941
1949	Hytherm copper[3]	Trace elements controlled to raise permissible normal and emergency operating temperature

Table 2 · CABLE SHEATHING MATERIALS

Year	Sheathing	Innovator	Cable
1838	Lead pipe	W. F. Cooke*	Telegraph
1845	Extruded lead sheath	W. F. Cooke, C. Wheatstone*	Telegraph
1884	Lead-tin alloy	Bell System	Telephone
1912	Lead-antimony alloy	Bell System	Telephone
1927	Lead-tin-calcium alloy	BNFMRA*†	Power
1927	Lead-antimony-calcium alloy	BNFMRA*†	Power
1930	Lead-calcium alloy	Bell System[5]	Telephone
1932	Lead-tellurium alloy	BNFMRA*†	Power
1944	Lead-arsenic-tin alloy	Anaconda Wire & Cable Company[6]	Power
1954	Lead-arsenic-tin-tellurium alloy	General Electric Company[7]	Power
1932	Rolled-down aluminum tube	Aluminum Company of America	Telephone
1939	Extruded aluminum sheath	Siemens-Schuckertwerke A. G.	Telephone
1948	Drawn-down aluminum tube	Johnson & Phillips, Ltd.*	Power
1947	Alpeth	Bell System	Telephone
1950	Stalpeth	Bell System[8]	Telephone

*Patented in England

†British Non-Ferrous Metals Research Association

nan[13] has said that dielectrics may be considered as a section of chemistry, or physics, or engineering, without regard to the other sciences, but the subject has depth only when it is illumined by the laws of all three.

Textile

Silk and cotton were the first insulating materials because they were available. In 1831, Joseph Henry used cotton thread saturated with beeswax. Cotton as used for magnet wire today is purified by removal of the electrolytic corrosion products and conducting salts,[14] and then applied under controlled temperature and humidity conditions.[15]

Glass fibers came into commercial production in 1931 and in a few years replaced cotton in many wire applications. Bonded with silicone varnish, Fiberglas is an excellent high-temperature insulation for magnet wire.

Varnish and Enamel

Saturants for cotton covering on early wires included beeswax, paraffin, gum shellac, and varnish. As early as 1832, Henry described a coil wound with

Table 3 · PAPER–OIL INSULATION

Year	Innovator	Development
1872	J. H. Wortendyke	Manufacture of paper-wrapped wire
1884	E. D. McCracken[16]	Patent for spirally wound paper taping process
1887	J. T. Jaques[17]	Patent for vacuum drying and hot impregnation, combined in one process
1887	David Brooks[18]	Use of London (rosin) oil–wood rosin impregnant
1888	Norwich Insulated Wire Company, et al.*	Manufacture of impregnated-paper cable with spirally applied tapes and extruded lead sheath (52-pair, no. 19 AWG telephone cable)
1909	J. T. H. Dempster[19]	Patent for cooling under pressure in impregnating tanks
1911	P. O. Keilholtz[20]	Patent for heating under vacuum by circulating current through conductors
1918	Cable Manufacturers	Use of wood pulp paper
1918	Cable Manufacturers	Use of petrolatum–rosin impregnant
1921	Cable Manufacturers	Use of unblended petrolatum impregnant
1925	Cable Manufacturers	Use of viscous mineral oil impregnant, with or without refined rosin or polyisobutylene

* Conductors were taped by Norwich, Harrison, N. J.; cabled by Kerite Company, Seymour, Conn.; oven-dried and impregnated with mixture of rosin oil-rosin, and lead-sheathed by John Robertson Company, Brooklyn, N. Y.

copper wire insulated with varnish. This was the forerunner of today's film-coated magnet wire.

Enamels and methods for their application to wire have been bettered by chemical research. The first major breakthrough came in 1938, with discovery that polyvinyl formal becomes plasticized when mixed with phenol, and that this mixture in turn can plasticize a phenolic varnish. The resultant material, Formvar, met with great success.

Film-coating materials of various types have been developed to fill increasing demand for longer life at higher temperatures in more compact equipment.

Gutta-Percha

The excellent insulating properties of gutta-percha were discovered by Faraday in 1845, and it was used in 1847 to insulate submarine cable laid across the North River in New York. The material continued in use for submarine and underground telegraph cables until replaced by polyethylene, about 1940.

Rubber

Rubber seems to have been first used as an insulant in 1811, when Samuel von Sommering transmitted signals from his electrochemical telegraph across the Isar River in Germany. His 27 wires were first insulated individually with rubber and silk thread, then bundled and covered with heated rubber. This 1,000-foot installation probably represented the first commercial use of copper wire to transmit electricity. In its description, we find the first use of the term "cable" as differentiated from "wire."

Rubber strip covering was developed in England in 1848. Vulcanized-rubber insulation was introduced by William Hooper of England in 1859. Extruded rubber-insulated wire was produced by the Kerite Company in 1866.

In the early 1920's, there was a sudden acceleration in rubber technology. Availability of new rubber chemicals, particularly antioxidants and organic accelerators, enabled chemists to effect improvements in rubber insulation. This specialty is one of the most demanding in chemistry, since electrical insulation must have excellent electrical characteristics as well as good physical properties.

Neoprene, introduced in 1931, is resistant to flame, oils, and chemicals, and is used for jackets over rubber insulation. Buna-N, buna-S, and Butyl rubber, World War II substitutes for natural rubber, have largely replaced it as insulation because their quality can be controlled. Silicone rubber resists heat and radiation and is excellent for power and control cables for seagoing vessels, for nuclear reactors, and for generator leads.

Paper and Petroleum

Although they involve separate technologies, paper and petroleum are used together in power cable; thus, they are grouped here for discussion. Dry paper is used primarily for paper-covered magnet wire and for telephone cable. Impregnated-paper developments for solid-type power cable are shown in Table 3.

Wood-pulp paper, now the major paper insulant, was at first poor in quality and owes its acceptance to research by cable and paper manufacturers.

Paper and oil research has been conducted intensively for 40 years by U.S. manufacturers. Aims are higher dielectric strength, lower dielectric losses, and long-time stability. One result of these efforts is the design of four different underground cables to transmit 500 mva at 345 kv under American operating conditions. These cables are now under field test.[21]

Plastic

Polyvinyl chloride, the first modern plastic wire insulation, was introduced in 1930. It is used for in-

terior wire, control cable, and as a jacket for rubber insulation. In Europe it is also used for medium-voltage power cable.

Polyethylene, developed in 1933, served during World War II as insulation for high-frequency cables and, when nylon-jacketed, for field telephone wire. Used after the war for television lead-in wire, its applications now include communication wire, medium-voltage power cable, and control cable. It has all but replaced braided weatherproof covering for overhead-line distribution wire. It has replaced gutta-percha for submarine communication cables because it has lower SIC, or specific inductive capacitance (2.2 vs. 3.0), greater stability at high temperatures, and greater resistance to attack by teredinidae. Cross-linking of polyethylene by vulcanization or irradiation indicates that the range of its applications may be widely increased.

Nylon makes an effective thin jacket over polyethylene insulation because of its abrasion resistance. Teflon and Kel-F are used for special applications requiring high temperature stability and chemical resistance. Plastics chemists have evaluated literally thousands of resins, fillers, plasticizers, and coloring agents, and have developed compounds with a wider operating temperature range, and jacketing materials compatible with major insulations.

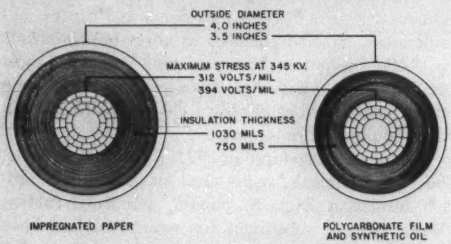


Fig. 1. Comparison of 345-kv paper vs. plastic-insulated lead-sheathed cables

Polycarbonate tapes and synthetic oil were used to manufacture an experimental 345-kv cable in 1958 with only 75 per cent of conventional impregnated-paper insulation thickness. Cyclic-load (aging) test showed that the cable has only one quarter the dielectric losses, hence greatly increased load capability.[22] Fig. 1 shows a comparison of the two cables. Further development is required for commercial production.

MECHANICAL ENGINEERING

Mechanical as well as electrical skills have made possible today's wide range in type and size of electric conductors by the design and improvement of the myriad pieces of complex equipment necessary to cable manufacture.

Wire drawing was introduced to the Colonies in 1660 by Joseph Jenks, who obtained the first machinery patent in America. In the 1830's, an American wire company insulated copper for electrical experiments by Joseph Henry and by Samuel F. B. Morse. The electrical wire and cable business is considered to have been created by the invention of the telegraph in 1837.

It would be impractical to outline the many developments that led to today's mechanized cable plant. It will suffice to mention the types of machinery used and to give one example of process development.

For techniques such as rod rolling, wire drawing, annealing, coating, and stranding, knowledge of metallurgy as well as mechanical engineering is necessary. Processes involving compound mixers, calenders, extruders, and vulcanizers for rubber and plastic insulation require co-ordination with the dielectrics specialist. Braiding, taping, and cabling processes must be carefully controlled. Drying and impregnating of paper insulation involve vacuum-and-pressure tanks, heating and cooling systems, and familiarity with thermodynamics. The use of lead calls for presses and extruders, melting kettles, and hydraulic pumps. Machinery for application of textiles, armor, and enamels must be designed, and changed as new materials come into use.

Lead Extrusion

Lead extrusion may serve as an example of mechanical process development. Although the first lead extrusion press was made in 1797, it was not until 1879 that progress was made in cable sheathing. Francois Borel of France developed a small hydraulic lead press which extruded metal in a semimolten state in the form of a sheath around the insulated conductor. B. H. Wesslau of Germany produced a small laboratory model extruder of a design by Werner von Siemens. It operated so successfully that a full-scale press was made in 1881, and the Siemens press remained in use for decades. It extruded a pipe over cable with moderate clearance. The pipe was later drawn or rolled down to fit closely.[18]

From the outset, Siemens adopted a high-pressure low-temperature method of cable sheathing, believing that high-temperature lead working produced porous sheaths. In the United States, John Robertson built a cold-slug press in 1857. In 1885, he improved Eaton's 1880 low-temperature high-pressure vertical press by producing one with the die block separate from the lead container.

Increasing failure rates of duct-lay lead-sheathed cables with oil-filled joints led to intensive metallurgical investigations in the 1930's. The result was improved mechanical processes, such as die-block temperature control, cleansing of cylinder charge by guillotine, and admission of molten lead from kettle to cylinder under vacuum, CO_2, or hydrogen. At the same time, several types of continuous screw-type extruders were introduced. These are still under development, especially for use with lead alloys.

STRUCTURAL ENGINEERING

Structural engineering concepts may seem outside the realm of cable application. Although the cable engineer does not do detail design for transmission towers, substation structures, underground duct lines, etc., he must know their design limitations if his cable installation is to be adequate.

Since overhead conductors may be considered "flexible structures," the cable engineer actually is required to do structural designing. Two examples will be given.

Overhead Lines

Calculation of sag-tension data for overhead transmission conductors based on catenary equations can be very intricate, particularly for composite conductors. Many factors must be considered, such as stress–strain characteristics of the metals, creep and inelastic set under varying sustained loadings, temperature changes, variations in external loadings, and differences in support elevation. Messenger supports for aerial insulated cables involve similar problems.

Radio Antennas

Radio communications involve high-power installations requiring extensive antenna arrays. Usually these are flexible cable structures supported by steel towers. A recent Navy installation in Maine will transmit on very low frequency to permit reception by submerged Polaris submarines, and can radiate 1 megawatt. The antenna resembles two giant 6-pointed stars, 6,200 feet from point to point, supported on 26 steel towers varying in height from 800 to 900 feet, and is designed to withstand winds of 150 knots with ice accumulation on the antenna to a 3-inch radius. Each panel can be switched to a de-icing circuit capable of freeing the cables of ice.

ELECTRICAL ENGINEERING

Electrical engineering principles and knowledge of electrical phenomena are used to determine the exacting requirements for cable materials. The electrical engineer co-ordinates the contributions of other disciplines. He designs the product and specifies manufacturing processes and acceptance tests, guides research and development, and participates in preparation of industry standards and recommended practices.

Cable engineering has many facets, as evidenced by the work of the 14 active subcommittees of the Insulated Conductors Committee of AIEE. For purposes of illustration, a more comprehensive grouping would be these three categories: Communication, Power, and Military Cable Engineering.

COMMUNICATION CABLE ENGINEERING

Cable for the transmission of intelligence includes a wide variety of constructions utilizing many different insulations and protective coverings. Some steps in the development of communication cable, particularly dry telephone cable, are cited:

Kelvin KR Law. Prof. William Thomson[23] (first Lord Kelvin) in 1854 developed the first serious telegraph cable theory: The time required for the received current to reach a stated fraction of its maximum strength is proportional to the capacitance, resistance, and the square of the length of cable.

Ground Return. In 1838, C. A. von Steinheil of Germany, while seeking to use a railroad track for the purpose, discovered that the earth could be used instead of a return wire to complete a telegraph line circuit. This important contribution to the art of telegraphy was adopted almost universally.

Cross Interference. In 1890, J. J. Carty[24] presented a paper describing experiments proving that the cause of cross interference between telephone circuits was electrostatic, not electromagnetic.

Impregnated Cable. The first telephone cables were composed of wires placed in pipes and sealed against moisture with oil, paraffin, or asphaltum. Early paper-wrapped cables were made with longitudinal strips of paper. As noted in Table 3, the first helically wrapped paper telephone cable was impregnated with oil.

Dry-Core Cable. In 1889, F. A. Pickernell* proposed, and in 1891 put into use, dry-core spirally wrapped paper-insulated lead-sheathed cables. Paper-taped insulation was supplemented in 1928 by a wood-pulp process developed by the Bell System.[25] Currently, 2,424-pair no. 26 AWG cables are being produced within the standard of 2⅝-inch outside diameter sheath. As a war conservation measure, 3,030-pair no. 28 AWG cables were manufactured in 1942, but found limited use.

Coaxial Conductor. The carrier system developed in 1918 uses different frequency bands separated by electric filters to carry a number of different messages simultaneously over one transmission path. A single open-wire pair can provide as many as 16 telephone circuits by this method. Carrier in cable was followed shortly by a new "coaxial" conductor, consisting of a ⅜-inch copper tube with a wire centered by insulating washers. Feedback amplifiers applied every 4 to 8 miles permit transmission of a very wide band of frequencies over a single coaxial conductor. Further developments in 1952 provided a frequency band nearly 8 mc wide so that two coaxials can provide either 1,800 telephone channels, or 600 telephone channels plus a 4.2-mc television circuit in each direction.[26]

POWER CABLE ENGINEERING

Cables for the transmission of energy also are varied in design and require insulating and protective materials of diverse characteristics. Development of impregnated-paper cable will be cited as an example.

*First Massachusetts Institute of Technology graduate to receive BS in EE, 1885.

Brooks Oil-Filled System

The Brooks oil-filled system, patented in 1878 by David Brooks,[27] consisted of jute-insulated telegraph wires pulled into an iron pipe which was filled with low-viscosity oil. His patent claims "the mode . . . of keeping the fibrous coverings of the wires in the pipes constantly *saturated* with an insulating liquid *under pressure* . . ." About 1887, he adapted this system to low-voltage distribution for electric lighting, using stranded conductors with jute insulation and viscous impregnant.

Hunter Gas-Pressure System

The Hunter gas-pressure system, invented in 1882 by R. M. Hunter,[28] consisted of conductors operated with dry air or gas in a pipe, under pressure maintained by a compressor at the station end and a relief valve at the other end. Interestingly, this predecessor of modern high-pressure gas-filled cable systems was conceived only 3 months after the opening of Edison's generating station in 1882.

Ferranti Tubular Main

In 1889, S. Z. de Ferranti pioneered in a-c underground transmission by installing 2-conductor concentric 0.27-square-inch (350 MCM) 10-kv tubular mains from Depford to London. Insulation between conductors, and over outer conductor, consisted of ozokerite (wax) impregnated paper rolled on radially in sheets 20 feet long. The annular space between insulation and pipe was filled with bitumen. The mains operated from 1891 to 1933.[18]

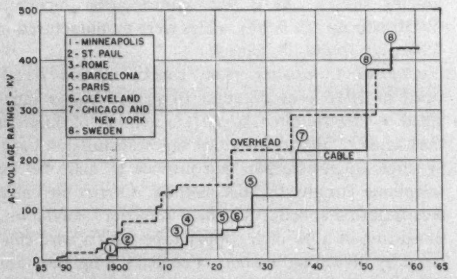


Fig. 2. Cable and overhead-line voltage ratings

Conductor Designs

Conductor designs patented for power cables were:

1885 . . . J. J. C. Smith	Hollow core
1887 . . . R. S. Waring	Concentric
1892 . . . S. Z. deFerranti[29]	D-shaped; sector shaped; shaped strips for concentric
1911 . . . C. H. Mertz and P. V. Hunter	Split-conductor

Ampacity Calculations

In 1893, A. E. Kennelly[30] developed an equation for calculating temperature rise in earth as a function of the cable system, its geometry, and thermal resistivity of the earth. Calculation of 1,400 current-carrying capacity (ampacity) tables for insulated cables is now being done by digital computer. This method[31] is new, but Kennelly's equation still provides the basis.

A-C Voltage Ratings

With the introduction of the a-c system by L. Gaulard and J. D. Gibbs of France in 1882, and invention of spirally wound paper tapes by McCracken in 1884, operating voltages for cables gradually increased as shown in Fig. 2.

Voltage Stress Reduction

M. O'Gorman[32] of England in 1901, E. Jona[33] of Italy in 1904, and A. Russell[34] of England in 1908 studied the reduction of stresses achieved by improving the shape and smoothing the surface of the conductor, and by "grading" the dielectric. The first involved reducing the sharp angular corners of shaped conductors, and using a larger number of similar wires for the conductor surface, even covering it completely in a thin metal sleeve. This technique is now referred to as conductor, or strand, shielding. Grading of the dielectric was designed to eliminate

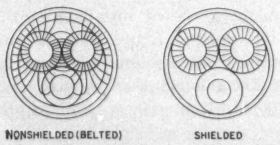


Fig. 3. Voltage stress distribution in 3-conductor cables when bottom conductor is at zero potential

concentration of stress in the zone nearest the conductor by applying concentric belts of insulating material, each with a lower permittivity (SIC) than its predecessor, to distribute the stress evenly through the dielectric.

High-Voltage D-C Cable

In 1906, two 150-kv cables, each 4 kilometers long, were installed in France on the Lyons–Moutiers line on a Thury d-c system. The cables operated at 75 kv to ground, but were insulated for 150 kv. In 1937, this d-c system was abandoned, with the cables still in good condition.[18]

Shielding

The shielding of cables to limit the electric stress to the active insulation and to remove the stress from dielectrically weak parts such as fillers in 3-conductor belted cables, as shown in Fig. 3, was patented by Martin Hochstadter[35] in Germany in 1913, and in the United States in 1916. He claimed " a high-tension cable . . . including in its structure . . . a thin layer of conducting material applied to the . . . insu-

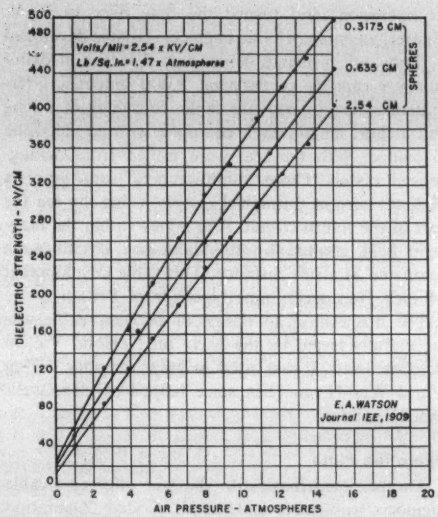


Fig. 4. Relation between dielectric strength and air pressure

lating material to the exclusion of air pockets." The logical construction is to omit the belt insulation in multiconductor cables, as suggested in Hochstadter's patent. Type *H* (shielded) cable eliminated the instability experienced with 3-conductor 33-kv belted cable and 1-conductor cable above 40 kv. Probably this is the most fundamental discovery in the power field to date for, without it, operating voltages above 25 kv would not have been practical. In 1920, the first installation of a 3-conductor 25-kv shielded cable was made at Fall River, Mass. By 1927, its efficacy was generally accepted.*

Oil-Filled Cable

In 1917, Luigi Emanueli[37] of Italy improved the Brooks system of 1878, and patented in Britain the low-pressure oil-filled cable. He employed a thin mineral oil which would respond readily to any volumetric change, and a central duct connected with elevated oil-pressure reservoirs. In 1924, the first experimental length was inserted in a 132-kv line at Brugherio, near Milan. In 1927, 18 miles of 1-conductor 132-kv cable was installed in New York and Chicago. In 1930, a 3-conductor 75-kv cable was initiated in Cincinnati.

Dielectric Strength vs. Pressure

In 1889, F. Paschen[38] introduced what became known as his law: At a constant temperature, the breakdown voltage is a function only of the product of the gas pressure and the distance between parallel-plane electrodes. Although it had been generally accepted that "the dielectric strength of air is proportional to its pressure," it remained for a student at Liverpool University, E. A. Watson,[39] to make in 1909 accurate measurements up to 200 psi, as shown in Fig. 4.

Compression Cable

The first gas-pressure cable installation was of the diaphragm, or compression, type developed in 1927 by Hochstadter,[40] W. Vogel of Germany, and E. Bowden of England. In 1931, a 2½-mile length of 3-conductor 69-kv cable was laid in a welded steel pipe in London. The paper-insulated conductors were cabled together and covered with a triangular lead sheath with rounded corners, a design by Hugo Sonnenfeld[41] of Czechoslovakia in 1926, called *SO* sheath. The sheath functioned as a diaphragm when operated in pipe filled with nitgrogen at 180 psi.

High-Pressure Oil-Filled Cable

In 1931, C. E. Bennett[42] introduced his high-pressure oil-filled (Oil-o-static) system consisting of three 1-conductor solid-type paper cables operated in a welded steel pipe filled with oil and maintained at 200 psi pressure. In 1932, an experimental installation of 3-conductor 69-kv cable was made by the Philadelphia Electric Company. In 1935, the first commercial installation of 132-kv 1-phase cable was made for the Pennsylvania Railroad at Baltimore.

Gas-Pressure Cable

The relation between pressure and dielectric strength precipitated a number of designs to effect a practical construction. Necessity for a diaphragm separating the dielectric from the pressure medium, as in compression cable, was not recognized by other designers. In 1925-26, H. W. Fisher and R. W. Atkinson[43] produced their patents on gas pressure applied directly to the dielectric to raise its breakdown strength to a point at which ionization of the vacuous spaces was suppressed. They also proposed that impregnating compound was necessary.

British Pressure Cable

British developments[44] of the high-pressure self-contained type included:

1932	C. J. Beaver, E. L. Davey	Gas-filled
1931-5	A. N. Arman	Dry gas pressure
1932	P. Dunsheath	Gas-cushion
1934	P. V. Hunter, L. G. Brazier	Impregnated gas-pressure

In 1944, the first 3-conductor 132-kv cable in the world was the impregnated-gas-pressure type installed at Burford in Oxfordshire.[45]

Gas-Filled Cable

In 1936, G. B. Shanklin[46] invented low-pressure gas-filled cable, which essentially is a mass-impregnated drained solid-type cable operated under 15 psi pressure. In 1-conductor cable, the sheath is fluted

*For a complete history and discussion of shielding, see reference 36.

to convey the gas longitudinally. In 3-conductor cable, a solid tube replaces one of the open helixes in the interstices, an improvement by J. K. Matsumoto[47] in 1939. The first trial installation of 3-conductor 15-kv low-pressure gas-filled cable was made in 1938 by the Yonkers (N.Y.) Electric Light and Power Company.

Carbon-Black Cable

Type *CB* was invented in 1934 by S. J. Rosch.[48] Chemically absorbent colloidal carbon black is added to wood-pulp insulating paper and slit into paper tapes, which are applied over the conductor and over the insulation during the insulating operation. In addition to absorbing deterioration products found in oil under heat and electric stress, the semiconducting carbon-black paper provides conductor shielding. Because carbon has a lower work function than metal, it also reduces the destructive energy released at the copper–paper interface. The first commercial installation was made in 1939 by the Westchester (N.Y.) Lighting Company.

High-Pressure Gas-Filled Cable

S. M. Dean suggested in the late 1930's that the Beaver-Davey[49] dielectric design be operated under 200 psi gas pressure in a steel pipe rather than reinforced lead sheath. This insulation consisted of paper tapes preimpregnated with a high-viscosity compound and graded in thickness from 2.5 to 5 mils from the conductor outward. Gaps between turns provide channels for gas passage. A 7-mile 120-kv line of this construction (type *SMD*) was installed in 1941 in Detroit.[50]

MILITARY CABLE ENGINEERING

Modern cable engineering for the Armed Services involves transmission of both intelligence and energy, sometimes in the same cable assembly. While many of the items are adaptations of civilian designs, some are unique with the military, having been developed in secrecy.

The U.S. Army was first to use electric conductors with its field-line telegraph between McClellan's headquarters and the front-line officers in Virginia in July 1861. The Navy's initial use was an incandescent lighting plant aboard the *U.S.S. Trenton* in 1883. Electricity as a motive power for all turrets, ammunition hoists, and auxiliary machines in war began on the cruiser *U.S.S. Brooklyn* during the Battle of Santiago in July 1898. Three examples of military cable development will be cited.

Buoyant Cable

At the start of World War II, one of Hitler's secret weapons was a mine designed to make ships assist in their own destruction, being detonated by a ship's inherent magnetic field. In November 1939, the British recovered an unexploded magnetic mine, analyzed its operation, and turned the data over to P. V. Hunter, an eminent cable engineer. Hunter developed a "buoyant" insulated cable, only 3 inches in diameter yet capable of carrying 3,000 amperes intermittently. Sets of buoyant cable, consisting of a long and a short length, each equipped with an electrode in contact with the sea, were trailed from demagnetized vessels. These "minesweepers" sent impulses of direct current through the cable, using the sea for part of the return circuit. Any mines within the magnetic field created by the cable–sea circuit were detonated at a safe distance. This cable development nullified Germany's mine blockade of Britain.

The first American design of buoyant cable was successfully tested by the Navy off Norfolk, Va., in October 1940. It was used in great quantity during World War II, and has since helped to clear well-mined harbors.

Operation Pluto

Another contribution to the war effort by cable engineers was not a cable at all. Coded "Operation Pluto," it required design and manufacture of 2,500-foot lengths of 4½-inch hollow lead-alloy tubing, reinforced with steel tape and armored with steel wire to withstand an internal bursting pressure of 3,500 psi. The pipes were welded into continuous 35-mile lengths and laid under the English Channel. Up to a million gallons of fuel a day were pumped through these pipelines to the Allied Forces in Europe after D-Day.

Polaris-Firing Submarines

More recent cable designs were required by nuclear Polaris missile-firing submarines for fast-rise digital data and synchro-resolver signals. Characteristic impedance, capacitance, capacitance unbalance, and attenuation were all critical parameters to be held within the closest possible limits. It was required that the cables be free from water leakage when subjected to 300 psi hydrostatic pressure on an open end. A cable sealant was developed to meet several electrophysical requirements: good adhesion to plastics, high film strength, low dielectric loss, and SIC approaching that of polyethylene.

CONCLUSION

Electric conductors are unique in that they are an integral part of every electric device and system. To design them capably, an engineer must be cognizant of the workings of the system or device of which the cable will be a component. Where once the cable specialist was concerned only with communication and power, today his sphere includes transmission of electric energy in every conceivable application, including electronics and space.

An energized conductor has been characterized in the term "live wire," which Webster defines as "a person of stimulating alertness and activity." A "live

wire" is what a cable engineer should be, for in his field he may make use of all his educational training, inventiveness, and originality, and have an incentive to keep up to date in many branches of science and engineering. Cable engineering is, indeed, a multidiscipline technology.

REFERENCES

1. W. Hoopes, N. A. Robertson. *U. S. Patent no. 867,659*, Oct. 8, 1907.

2. Standard Handbook for Electrical Engineers (book), McGraw-Hill Book Company, Inc., New York, N. Y., ninth edition, 1957, sec. 4-58.

3. Hy-Therm Copper—An Improved Overhead-Line Conductor, L. F. Hickernell, A. A. Jones, C. J. Snyder. AIEE *Transactions*, vol. 68, 1949, pt. I, pp. 22-30.

4. Connecticut Pioneers in Telephony (book), J. L. Walsh. Morris F. Tyler Chapter, Telephone Pioneers of America, New Haven, Conn., 1950.

5. R. S. Dean. *U. S. Patent nos. 1,890,013-4*, Dec. 6, 1932.

6. G. E. Johnson, W. H. Bassett, Jr. *U. S. Patent no. 2,300,788*, Nov. 3, 1942; W. H. Basset, Jr., C. J. Snyder. *U. S. Patent no. 2,375,755*, May 15, 1945.

7. J. F. Eckel. *U. S. Patent no. 2,588,095*, Mar. 4, 1942.

8. H. G. Johnstone. *U. S. Patent no. 2,589,700*, Mar. 18, 1952.

9. F-3 Alloy Sheath—Effect of Bending and Creep on Life, L. F. Hickernell, A. A. Jones, C. J. Snyder. AIEE *Transactions*, vol. 70, pt. II, 1951, pp. 1273-85.

10. Cable Sheathing in Aluminum. *Light Metals*, London, England, vol. 9, 1946, pp. 474-98.

11. Cable Sheathed with Aluminum—Development in Great Britain, P. M. Hollingsworth. *Paper no. 203*, CIGRE, Paris, France, 1950.

12. Bell System Cable Sheath Problems and Designs, F. W. Horn, R. B. Ramsey. AIEE *Transactions*, vol. 70, pt. II, 1951, pp. 1811-6.

13. The Present Status and Anticipated Progress in the Field of Insulating Materials, T. D. Callinan. *Ibid.*, pt. I *(Communication and Electronics)*, vol. 78, Mar. 1959, pp. 22-28.

14. Purified Textile Insulation for Telephone Central Office Wiring, H. H. Glenn, E. B. Wood. *Ibid.*, vol. 48, Apr. 1929, pp. 576-81.

15. Effect of Atmospheric Humidity and Temperature in the Relation between Moisture Content and Electrical Conductivity of Cotton, A. C. Walker. *Bell System Technical Journal*, New York, vol. XII, Oct. 1933, pp. 431-57.

16. E. D. McCracken. *U. S. Patent no. 304,539*, Sept. 2, 1884.

17. J. T. Jaques. *U. S. Patent no. 369,793*, Sept. 13, 1887.

18. Development of Power Cables (book), P. V. Hunter, J. T. Hazell. George Newnes, Ltd., London, England, 1956.

19. J. T. H. Dempster. *U. S. Patent no. 917,018*, Apr. 6, 1909.

20. P. O. Keilholtz. *U. S. Patent no. 994,931*, June 3, 1911.

21. Extra-High Voltage Cable Conference. AIEE *Special Publication T-129*, Mar. 1961.

22. Insulation Breakthrough Yields All-Synthetic 345-Kv Cable, L. F. Hickernell, E. D. Eich. *Electrical World*, New York, vol. 155, no. 16, Apr. 17, 1961, pp. 60-62.

23. On the Theory of the Electric Telegraph, William Thomson. *Proceedings*, Royal Society of London, vol. 7, May 24, 1855, pp. 383-99.

24. Inductive Disturbances in Telephone Circuits, J. J. Carty. AIEE *Transactions*, vol. 8, 1890-1, pp. 100-26.

25. Pulp Insulation for Telephone Cables, H. G. Walker, L. S. Ford. *Ibid.*, vol. 52, Mar. 1933, pp. 133-41.

26. Telephone, E. I. Green. "Encyclopaedia Brittanica," Chicago, Ill., 1957, pp. 895-906; also *Monograph no. 2806*, Bell Telephone System, New York.

27. David Brooks. *U. S. Patent no. 210,986*, Dec. 17, 1878.

28. R. M. Hunter. *U. S. Patent no. 275,387*, Apr. 10, 1883.

29. S. Z. de Ferranti. *British Patent no. 22,923*, Dec. 13, 1892.

30. On the Carrying Capacity of Electric Cables, Submerged, Buried, or Suspended in Air (Pts. I and II), A. E. Kennelly. *Electrical World*, vol. 22, no. 10, Sept. 2, 1893, p. 183; no. 11, Sept. 9, 1893, pp. 201-2.

31. The Calculation of Temperature Rise and Load Capability of Cable Systems, J. H. Neher, M. H. McGrath. AIEE *Transactions*, pt. III *(Power Apparatus and Systems)*, vol. 76, Oct. 1957, pp. 752-72.

32. Insulation of Cables, Mervyn O'Gorman. *Journal*, Institution of Electrical Engineers, London, vol. 30, 1901, pp. 608-701.

33. Insulating Materials in High-Tension Cables, Emanuele Jona. *Transactions*, International Electrical Congress, St. Louis, Mo., vol. 2, 1904, pp. 550-71.

34. The Dielectric Strength of Insulating Materials and the Grading of Cables, Alexander Russell. *Journal*, Institution of Electrical Engineers, vol. 40, 1908, pp. 6-60.

35. Martin Hochstadter. *U. S. Patent no. 1,199,789*, Oct. 3, 1916.

36. Shielding of Insulated Power Cables, L. F. Hickernell. *Publication C-59*, Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., second edition, Sept. 1946.

37. Luigi Emanueli. *British Patent no. 114,414*, Oct. 10, 1918.

38. Potential Difference Required for Sparkover in Air, Hydrogen, and Carbon Dioxide at Various Presures, Friedrich Paschen. *Wiedemann Annalen*, Liepzig, Germany, vol. 37, 1889, p. 69.

39. The Dielectric Strength of Compressed Air, E. A. Watson. *Journal*, Institution of Electrical Engineers, vol. 43, 1909, pp. 113-49.

40. Martin Hochstadter. *U. S. Patent nos. 1,849,624 and 1,849,873*, Mar. 15, 1932.

41. Hugo Sonnenfeld. *U. S. Patent no. 1,838,332*, Dec. 29, 1931.

42. C. E. Bennett. *U. S. Patent no. 2,015,063*, Sept. 24, 1935.

43. H. W. Fisher, R. W. Atkinson. *U. S. Patent no. 1,524,124*, Jan. 27, 1925; H. W. Fisher. *U. S. Patent no. 1,574,076*, Feb. 23, 1926.

44. Modern Supertension Cables (Pts. I, II, and III), C. C. Barnes. *The Electrician*, London, vol. 39, July 18, 1947, pp. 189-91; Aug. 1, 1947, pp. 329-32; Aug. 8, 1947, pp. 397-99.

45. Underground Transmission by Means of a 3-Core 132-Kv Impregnated-Pressure Cable, L. G. Brazier. *Paper no. 212*, CIGRE, 1946.

46. G. B. Shanklin. *U. S. Patent no. 2,253,986*, Aug. 26, 1941.

47. J. K. Matsumoto. *U. S. Patent no. 2,261,742*, Nov. 4, 1941.

48. S. J. Rosch. *U. S. Patent no. 2,102,129*, Dec. 14, 1937.

49. The Gas-Filled Cable, C. J. Beaver, E. L. Davey. *Paper no. 204*, CIGRE, 1937.

50. 120-Kv High-Pressure Gas-Filled Cable, I. T. Faucett, L. I. Komives, H. W. Collins, R. W. Atkinson. AIEE *Transactions*, vol. 61, 1942, pp. 658-65.

Union Electric's Meramac power plant, being completed by MacDonald, Frazier-Davis and Associates, can generate 933 mw. It is believed to be the largest single construction project in the St. Louis metropolitan area.

RICHARD McFEE

Superconducting power transformers — a feasibility study

Increased efficiency is the main benefit of superconductivity. Some power is needed to operate the refrigerator but it is extremely small. Reduction in transformer size is also important. Other advantages include an improvement in power factor, extended life, and automatic limiting of short circuits.

Electrical resistance of transformer windings is responsible for a significant fraction of the cost of electric power. Part of this cost represents direct loss in the form of electric heating. Another portion results from the expense associated with the large size required to reduce and dissipate the heat generated in the electrical resistance. The heat itself also accelerates deterioration of insulation.

Because of these economic factors, use of superconductors in place of copper wires has been an attractive prospect ever since superconductivity was discovered over a half-century ago. Superconducting wires have not been used for several reasons. First, superconductors cannot withstand strong magnetic fields. When they are subjected to fields weaker than those usually found in transformer coils, electrical resistance reappears. With superconducting transformers of conventional construction this quenching current level is so low that the maximum power rating is smaller than that of conventional transformers of the same size.

Another problem with superconducting transformers is the load imposed on the refrigerator by the hysteresis and eddy-current losses in the core. At superconducting temperatures, each watt of heat extracted requires over a kilowatt of input to the refrigerator. Over-all efficiency of the transformer is therefore very low.

One approach to the quenching problem is to use a special superconductor capable of withstanding strong magnetic fields. Such a material has been developed recently.[1] Its ability to carry large direct currents has been demonstrated but it is not yet known if it can handle alternating currents without excessive losses of resistive, magnetic, or dielectric origin.

Essentially full text of conference paper CP 61-809 presented at the AIEE Summer General Meeting, Ithaca, N. Y., June 18-23, 1961, at a session sponsored by the AIEE Transformers Committee.

Richard McFee, Member AIEE, is with Syracuse University, Syracuse, N. Y., and Arthur D. Little Inc., Cambridge, Mass.

An alternative approach is to prevent build-up of the magnetic field within the coil or conductors. Each wire of the coil adds its field to that of the others until a sum is reached which exceeds the strength of the critical magnetic field. If this build-up of the field could be prevented, substantial currents could be handled and superconductivity might find practical application to power transformers.

In the following analysis it is shown that the field build-up can be prevented by interleaving the primary and secondary conductors. The result is a large increase in current capacity and a corresponding increase in power rating. For example, a superconducting transformer coil designed to operate with a 10-kilogram core normally capable of handling 5 kva, can be designed to handle as much as 500 kva.

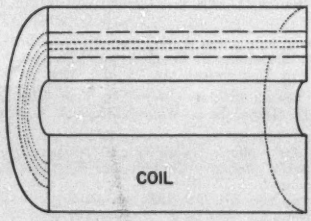


Fig. 1. One type of winding unit. Two primary layers are on the outside and two secondary layers on the inside

The chief practical problem with superconducting transformers is the period required to recool the windings after they have been quenched on current surges. Quenching can be prevented by use of external reactors to limit surge currents but at a cost of substantial reduction in transformer rating and deterioration of power factor. Other means of protection are also possible.

Another practical problem is that of obtaining reliable refrigeration. No cryostat now in production is sufficiently reliable for this application. However,

the new Gifford-McMahon refrigeration cycle[2] promises ultimately to give cryostats the same order of reliability as is now obtained with household refrigeration equipment.

SUPERCONDUCTING TRANSFORMERS

When a voltage is applied to the primary of an unloaded transformer, a flux is produced in the core which induces a counter voltage almost exactly equal to the applied voltage. The difference between the applied and the induced voltage is just sufficient to propel the small magnetizing current through the coil which generates the core flux. When a current is drawn through the secondary, an additional current flows through the primary in such fashion as to prevent a change in flux. Since the mmf (magnetomotive force) causing the flux is proportional to the total current circulating about the core, this current is essentially zero, regardless of the load on the secondary.

It is the equal and opposite character of the total primary and secondary currents which encircle the core that leads to the possibility of practical superconducting transformers. Only the magnetizing current interferes with this symmetry, and it is small.

If the primary and secondary coil layers are interleaved, they will carry current in opposite directions. These oppositely directed current sheets produce equal but opposite magnetic fields. The magnetic fields, therefore, do not build up and the superconductors can carry large amounts of current without quenching. A large variety of methods exists for interleaving the windings. These include cylindrical layers, pancake windings, foil windings, coaxial, and others.

One especially useful type of winding unit is that shown in Fig. 1. It consists of an inner primary layer, two secondary layers, and an outer primary layer. Some advantages of this arrangement are that the external field is extremely small, and that heavy insulation is required only between every other layer

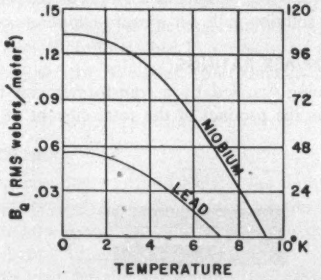


Fig. 2. Quenching flux density and surface current density of lead and niobium

rather than every layer. The quenching current densities are those shown in Fig. 2.

The number of turns in the primary and secondary layers need not be the same. A number of such units placed one on top of another will not interact. They may be placed in series or parallel or series-parallel to suit the over-all transformation ratio required.

Superconducting transformers can also employ conventional core or shell-type magnetic circuits and

---

THE RELEVANT PROPERTIES OF SUPERCONDUCTORS

The properties of superconductors which are of particular interest here are outlined below. For further information, the reader is referred to Schoenberg.[3]

First, superconductors have zero electrical resistance and, hence, no heat is generated by current flow. The current flows on the surface of the conductor rather than within it, distributed through a layer on the order of 10^{-5} cm thick. As a result, very thin superconducting films can carry currents as great as solid bars. This fact can mean great savings in weight and space in superconducting devices.

Second, many superconductors are perfect magnetic insulators and exclude all magnetic flux. This, too, is a surface phenomenon. Thin cylinders are just as effective magnetic insulators as solid bars. Exceptions to this rule occur with nonideal superconductors such as stressed niobium or niobium nitride.

Third, superconductivity can be quenched by heat, magnetic fields, and surface currents. For any given material, there is a critical temperature T_Q above which normal resistance is found. At any specified temperature, there are also critical surface field densities B_Q and surface current densities J_Q above which superconductivity disappears. Impurities and mechanical strain may produce drastic changes in these critical densities although some materials such as lead can withstand high concentrations of certain impurities without appreciable change in their superconducting properties.

In pure unstrained metals such as lead or tin, the critical current density J_Q and the critical field density B_Q are closely related. The density J_Q is precisely that required to terminate an external field B_Q giving zero internal field. That is

$$B_Q/\mu = J_Q$$

The superconductor thus acts as if its magnetic properties derive from the fact that it has zero electrical resistance. In other words, the magnetic field is screened out by eddy currents induced on the surface. Quenching occurs when the surface currents exceed the maximum surface density value J_Q.

The attractively simple relationship just described (Silsbee hypothesis) does not apply to nonideal superconducting materials.

can be operated on single or polyphase connections. The only special design problem other than that of interleaving is thermal insulation. As has been pointed out, this problem arises because the core must be kept at normal temperatures. If it were cooled along with the coil, an enormous refrigerator would be required to extract the heat generated by hysteresis and eddy currents. Ferrite cores can drastically reduce eddy currents but hysteresis losses will remain. The practical solution calls for a room-temperature core.

TRANSFORMER RATINGS

Power being handled by a transformer can be expressed as the product of the total current of either

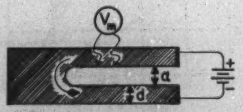


Fig. 3. Sketch of a paper model used to estimate the strength of the magnetic field at the ends of the coil

the primary or secondary windings encircling the core multiplied by the voltage of a single turn. Total circulating current can be expressed in terms of the average current density of the core window. This is defined here as the sum of the rms values of the circulating currents of the primary and secondary windings divided by the cross-section area of the core window. If the power is designated by P, the average current density by J, the window area by A_w and the rms turn voltage by V_t, then

$$P = \tfrac{1}{2} J A_w V_t \qquad (1)$$

In conventional transformers, J is limited by the maximum amount of heat which may be generated per unit volume; a factor established in turn by the maximum allowable temperature rise. Maximum current density J decreases at higher voltages since more of the coil cross-section area is required for insulation and the current is forced through a smaller cross section of copper, thus producing more heat. Experience shows that for large, high-power transformers, J can be approximated:

$$J = F/V^{1/4} \qquad (2)$$

where F is a constant and V is the maximum voltage level of the transformer.

In superconducting transformers the maximum allowable current density is limited by entirely different factors. The first of these is the quenching level of the superconductor, determined by the material and temperature as shown in Fig. 2. The second is the spacing of the superconducting layers. The latter is determined mainly by the dielectric strength of the insulation. If this strength is very high, then the insulation thickness can be made very small and a large number of superconducting layers can be sandwiched into a given cross-section area. The average current density is then high and the power capability of the transformer correspondingly so.

The dielectric strength of insulation at liquid-helium temperatures is somewhat better than at room temperature. There is no ionic conduction. Vacuum insulation can also be used in superconducting transformers since no heat is generated and no medium is required to conduct it away. It seems likely that the dielectric strength of vacuum insulation will improve at low temperatures, since the low temperatures of the surfaces involved will tend to inhibit electron emission.

Premature quenching of superconducting windings can occur at the ends of the coils where the flux passes around a sharp corner. If the width of the channel carrying the flux is small compared to the radius of the corner at the end, this effect is minor. In this case, the flux is already squeezed in the channel and fans out when it emerges with a corresponding reduction in flux density. But if the channel is wide and the corner is sharp, then the flux attempts to take the path of least resistance, to hug the corner, and increased flux density causes premature quenching.

Studies with Teledetos paper models which simulate the behavior of the magnetic field have shown that for the values of channel width and corner radius specified in Fig. 3, the maximum current-carrying capacities of the windings will be reduced by the factor α shown in Fig. 4. It appears likely that such premature quenching can be avoided through the use of nonideal superconducting end caps which do not carry current and which quench only in very high-magnetic fields. This scheme has not yet been tested experimentally.

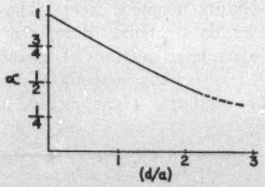


Fig. 4. Reduction in current-carrying capacity due to premature quenching at the coil ends. This reduction can be prevented through use of special end caps

Maximum coil current densities of superconducting transformers can be calculated by multiplying the quenching level of the superconductors by the reciprocal of the average spacing of the layers. The former is J_0 and the latter is an average of the thickness d of the primary-secondary insulation and the lesser thickness of the primary-primary or secondary-secondary insulation. The average spacing may be designated by βd where β is a factor which depends on

transformer construction and lies somewhere between one-half and one. If one assumes that a fraction η of the window area of the core is occupied by windings and that the primary-secondary insulation thickness is governed by the commonly used equation

$$d = KV^C \tag{3}$$

where K is a constant depending upon the material and C another constant, usually of the order of 3/2, then the quenching window current density is

$$J_{\max} = \eta\alpha J_Q/\beta KV^C \tag{4}$$

Taking C to be three-halves, comparison with equation 2 for conventional transformers shows that the window current density of superconducting transformers decreases more rapidly with voltage than that of the conventional type. An absolute comparison of the two is given in Fig. 5. This figure shows that superconducting transformers will have considerably higher power capabilities than conventional transformers of the same size and shape.

It is unlikely that superconducting transformers will have the same shape as is now common. Conventional designs select a ratio of winding cross section to core cross section, which minimizes the combined costs of steel and copper as well as the anticipated costs of the steel and copper electrical losses taken during the life of the transformer. Since winding losses of superconducting transformers are zero and the windings will probably be inexpensive (thin films of lead or niobium will be used for conductors), it will probably be economical to make the winding cross sections relatively large, thus minimizing the cost of the core and core losses.

The relationship between the weight of a superconducting transformer and its power-handling capacity is the same as that for one of conventional design. Its rating varies as the four-thirds power of its weight. This is established by equation 1 in combination with the fact that the turn voltage is proportional to the core cross-section area. From equation 1 it may be seen that if the dimensions of the transformer are doubled, its power rating is multiplied by 16. As the weight is simultaneously increased by a factor of 8, it is evident that the four-thirds exponent applies.

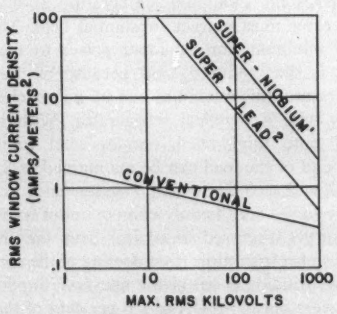


Fig. 5. Approximate window current density for large transformers, both conventional and superconducting. In the latter it is assumed that temperature is 4.2 K, η is 1/2, α is 0.9, β is 0.6, c is 1.5, and K is such that 4 cm of insulation withstands 1,000 kv. Since power-handling capacity is proportional to density, the curves also show the relative capacities of conventional and superconducting transformers employing the same cores

Since the power rating varies as the weight to the four-thirds power (with voltage constant) and inversely as voltage to the three-halves (with weight constant), it follows that in superconducting transformers, weight W varies approximately as follows

$$W \sim P^{3/4}V^{9/8} \tag{5}$$

EFFICIENCY

In superconducting transformers, the input power to the refrigerator accounts for part of the losses and the hysteresis and eddy currents of the core for the remainder.

The load on the refrigerator includes the input leads to the windings as well as the heat shield which is needed to insulate the windings thermally. The windings are also warmed by heat which leaks in via the thermal insulation and by dielectric losses. Available data on dielectric losses indicate that they are very small at liquid-helium temperatures and can be neglected. As the thermal heat leak to both winding and heat shield can be reduced to low level by careful mechanical design, they too can be neglected. The main load on the refrigerator is the heat conducted to the windings via the input leads.

If the leads are made long and thin, their electrical resistance becomes high, and excessive heat is generated in the leads themselves. If the leads are made short and thick, the heat conducted through them is excessive. A relatively sharp optimum ratio[4] of length to diameter exists which minimizes the heat arriving at the windings. At this optimum the heat flow $\dot{Q}$ is given by

$$\dot{Q} = I\,[(K/\sigma)_{av}\,(T_H - T_L)]^{\frac{1}{2}} \tag{6}$$

where I is the rms current. k the thermal conductivity, σ the electrical conductivity, T_H the temperature of the hot end, and T_L the temperature of the cold end. The average of the ratio of k and σ is taken over the temperature interval T_H to T_L.

From equation 6 it may be seen that the minimum heat flow is proportional to the current. This means that at a given transformer rating, the refrigerator load will be greater at low voltages and high currents than at high voltages and low currents.

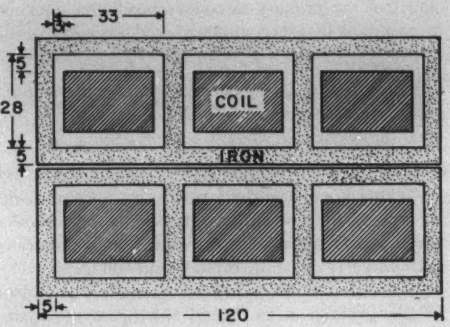
For every watt of heat removed from the coils, over a kilowatt of heat input power must be supplied to the refrigerator. The second law of thermodynamics accounts for some of this discrepancy. An ideal refrigerator requires a 99-watt input to extract one watt at 3 K and eject it at 300 K. The minimum multiplying factor M is

DESIGN OUTLINE FOR A SUPERCONDUCTING TRANSFORMER

The following paragraphs outline design features of a 120-mva, 13.2 to 115 kv, 60-cycle, 3-phase superconducting transformer. This transformer, when handling rated power, is operating at 75 per cent of its quenching level. It is presumed to be protected from current surges by very fast-acting circuit breakers. Winding connections are delta (low voltage) to Y (high voltage).

The conductors are niobium strips, 0.001 inch thick. The insulation is impregnated paper, graded in thickness, with a maximum thickness of 0.4 inch. Tempered niobium end caps prevent premature quenching at the ends of the windings.

Conductors are wound in three cylindrical coils, each containing 24 winding units with four layers per unit, two of which are low-voltage (153 turns per layer) and two high-voltage (65 turns per layer). All high-voltage layers are in series. Magnetizing windings are employed to permit paralleling of low-voltage layers. Core is M-6 grade magnetic steel and yields 21.6 volts per turn. Total core weight is 8,600 pounds. Computed core loss is approximately 6 kw and magnetizing volt-amperes, 6 kva. The configuration of core and coil is as illustrated.



Cross section of the core of a 120-mva superconducting transformer. Dimensions are in inches

Estimated refrigeration power is 18 kw and efficiency 99.98 per cent. The reactance factor is computed to be 3.8 per cent.

$$M = (T_H/T_L) - 1 \qquad (7)$$

At temperatures between 20 and 300 K actual refrigerators require from 2 to 4 times as much power input as the theoretical minimum. At temperatures below 20 K, efficiencies drop drastically and between 5 to 100 times the theoretical power is needed for cooling.

It is much more economical to cool an input lead in more than one stage. Suppose that an ideal refrigerator is available, that the current is 1 ampere, and that k/σ is 10^{-6}. If the high temperature is 300 K and the low 3 K, then, according to equations 6 and 7 the refrigerator input required is 17 watts. If the lead is now broken up into two parts, one bridging the interval from 300 to 30 K and the other from 30 to 3 K, the first requires 1.5 watts of refrigeration input, and the second 0.5 watt. The combined total is 2 watts. This is about one-tenth the single-stage requirement.

The ratio of k to σ for copper decreases by over two orders of magnitude as the temperature approaches absolute zero. The decrease becomes more marked as the purity of the copper is increased. Thus for minimum refrigerator load, it is important that the very highest purity copper be employed in the last stage of the input lead which connects to the winding.

Analysis of a 3-stage input lead of "electrolytic tough pitch" copper successively bridging the intervals between 300, 77, 20, and 4.2 K indicates that a refrigerator of modern design will require an input of approximately 1 watt for each ampere carried by the lead.

This means that a 10,000-kva single-phase transformer operating with low-voltage winding at 10 kv and high at 100 kv, with two leads carrying 1,000 amp and two carrying 100 amp, will require a refrigerator input of about 2,000 watts or 0.022 per cent of the power handled by the refrigerator. This figure can be reduced by use of higher quality copper in the leads. It can also be reduced by constructing the last stage of the input lead with a superconductor plated onto a support of high thermal resistance. Essentially zero heat is introduced into the coils by this arrangement. The high temperature end of this lead establishes the minimum temperature at which the refrigerator must extract substantial heat. The theoretical minimum for the input power to the refrigerator is thus reduced, and because of the higher temperature, this minimum can be approached more closely with a practical refrigerator. With niobium plated onto thin-walled stainless-steel tubing, the upper end of the lead can be maintained at 8 K, and the coil at 2 or 3 K.

Core losses are the only component of transformer loss not yet discussed. It is clear from the preceding analysis of refrigerators, that cooling of the core along with the winding is out of the question. Suppose core losses were only 1/100th of 1.0 per cent of the transformer rating. At roughly 1,000 watts, refrigerator input per watt extracted, the refrigerator load would be 10 per cent of the transformer rating, and the refrigerator corresponding large. This is why the core must be operated at normal temperatures.

Core losses in modern magnetic materials are on the order of 2 watts per kilogram at 60 cycles and

normal flux strengths. They are determined by the volume of the iron, and are larger in superconducting transformers operating at higher voltages, because the transformers are larger. In preliminary designs of some superconducting transformers, core losses on the order of 0.05 per cent of peak rating have been typical.

The manner in which the ratio of transformer loss to transformer rating varies as a function of rating and voltage is determined by both refrigerator power and core losses. The ratio of the refrigerator power to the transformer rating is inversely proportional to voltage, since the cooling power is proportional to current, and the rating is the product of volts and current. The ratio of core losses to rating varies as the weight divided by the power rating. In accordance with the relationship between power and weight, equation 5, this is $V^{9/8}/P^{1/4}$. Total fractional losses l therefore vary as below.

$$l \sim 1/V + G\,(V^{9/8}/P^{1/4}) \tag{8}$$

where G is a constant. It is evident that at any specified power level a minimum loss ratio exists at some voltage, below which the refrigerator losses predominate and above which the core losses predominate. For large transformers this minimum is on the order of 100 to 500 kv.

LEAKAGE REACTANCE

The flux density in the coils of superconducting transformers is greatly reduced by the interleaving of the primary and secondary windings. As a result there is little reactance to the flow of load currents. With no resistance and small inductance the regulation of the transformer is quite small.

Fig. 6 shows the flux induced by load currents in the basic winding unit previously sketched in Fig.1. The flux circulates about the secondary windings inducing a voltage $N(d\varphi/dt)$. No flux encircles the primary windings and no voltage is induced there.

Fig. 6. Leakage flux path in a cross section of the top part of the winding shown in Fig. 1

The ratio of the voltage induced by flux generated by full load currents, to voltage induced by core flux (B_cA_c), is the "reactance factor" of the transformers. At the quenching level the leakage flux is the quenching flux density αB_Q multiplied by the area A_f of the flux channel. If the quenching level is taken as "full load," the reactance factor R is therefore

$$R = \alpha B_Q A_f / B_c A_c \tag{9}$$

If the full load is taken as some fraction of the quenching level, the reactance factor is that given above multiplied by the same fraction.

The reactance factor is larger for the outer windings of superconducting transformers than the inner since the periphery of the outer windings is greater and hence A_f also. The reactance factor increases with voltage, since insulation thickness is increased and A_f with it. It is also higher for niobium windings than lead, since B_Q is higher.

Reactance factors of preliminary designs of various superconducting transformers seem to run on the order of 1 to 4 per cent.

VOLTAGE AND CURRENT SURGES

The ability of low-temperature insulation to withstand voltage surges does not seem to have been measured. It is unlikely that superconducting transformers will differ essentially from the conventional type in this respect and will call for overhead ground wires on transmission lines and lightning arresters at the stations. External air reactors can also help provide protection against sharp voltage pulses.

Superconducting transformers will react differently from ordinary transformers to current surges. If the surge remains below the quenching level, the transformer will not be disturbed. But if the current exceeds the quenching level, resistance will return to the winding and it will heat up. Very fast-acting circuit breakers are required to shorten this heating interval, and to reduce thereby the necessary time required for the transformer to recool.

The recooling period of these transformers is probably their most important drawback. In power distribution systems many short circuits occur which are rapidly cleared by circuit breakers, or last only briefly, as for example when ice-clad cables of transmission lines are blown together temporarily in windstorms. Operation immediately after such short circuits is essential.

If the short-circuit current of superconducting transformers is limited by external reactors to a value below the quenching level, the necessity of a recooling interval will be eliminated. For example, if the total reactance is 12½ per cent that of the rated load, and if the transformer at rated load is operating at 10 per cent of its quenching level, then the current after a short circuit will reach only 80 per cent of the quenching current. The loss in transformer rating, and the lagging power factor introduced by the external reactor will of course be disadvantages of this method. Nevertheless, the gain in transformer efficiency may more than offset these drawbacks.

The superconducting transformer can also be backed up with another transformer of conventional design which is switched in during the recooling period. Because the latter is used only intermittently, it can be operated at higher power levels than another of the same size designed for continuous duty.

Another approach requires the development of a circuit breaker which can sense the onset of current increase and operate fast enough to prevent the current from reaching the quenching level. A switching

time on the order of ½ millisecond would perhaps provide protection to a superconducting transformer operating at about half its quenching level. It is doubtful whether mechanical circuit breakers can attain this objective but it does seem possible that superconducting switches operating on the cryotron principle might achieve the response speed needed.

PARALLELING WINDINGS

Flux produced in superconducting windings by the magnetizing current will result in slight inequalities in the enclosure of flux by different turns. If all of the windings are in series, the resulting voltage unbalances will not interfere with the operation of the transformer. If, however, the windings are paralleled, circulating currents will be set up which equalize the total flux enclosure of the paralleled circuits. This will cause the magnetizing current to redistribute itself and bring about current flow in paralleled secondary windings even at no load. It is important to know the strength of these circulating currents. If sufficiently strong, they can lead to a reduction in the maximum load current that the transformer can carry, and a resultant reduction in its power-handling capacity.

The pattern of the circulating currents is established by the manner in which the windings are paralleled. For example, if all primary layers are paralleled and if all secondary windings are in series, equilibrium is established when the voltages of all primary windings are equal. This requires that the flux density be zero at all points within the coil. This in turn requires that all magnetizing current flow in the inner and outer layers. The problem becomes more complicated when primary and secondary windings are paralleled simultaneously.

One approach to the problem is to eliminate it. This can be achieved by designing the transformer so that the magnetizing current is carried by special windings on the inside and outside of the coil structure. These windings do not carry load currents. The magnetizing current component of the flux is thereby made zero within the coil and the voltages of all windings are identical. Primary and secondary windings can then be placed in series and parallel in any combination without setting up circulating currents.

CONCLUSIONS

Superconducting transformers are feasible provided that the core is operated at normal temperatures to reduce refrigerator load and the primary and secondary windings are interleaved, to prevent premature quenching of superconductivity by magnetic fields within the windings.

Potential advantages of these devices include small losses, high power ratings and low reactance factors.

Their main drawback appears to be the recooling interval required if the superconductor is permitted to quench on current surges. This quenching can be prevented through the use of external reactors, but at a loss in power rating and power factor. Development of a very fast-acting circuit breaker would furnish an ideal answer to this problem.

A new refrigeration cycle promises to provide the reliable cooling required by these devices.

REFERENCES

1. Superconductivity in Nb_3Sn at High Current Density in a Magnetic Field of 99 kgauss, J. E. Kunzler, E. Buehler, F. S. L. Hsu, J. H. Wernick. *Physical Review Letters*, New York, N. Y., vol. 6, no. 3, Feb. 1, 1961.

2. Progress in Cryogenics (book), W. E. Gifford, Heywood and Company, Ltd., London, England, vol. 3, 1961, pp. 49-73.

3. Superconductivity (book), D. Shoenberg. Cambridge University Press, Cambridge, England, 2nd edition, 1952.

4. Optimum Input Leads for Cryogenic Apparatus, R. McFee. *Review of Scientific Instruments*, New York, N.Y., 1959, p. 98, vol. 30.

Pattern of Holes

Huge plates drilled on a new multi-spindle drill are shown being installed in a large condenser for Baltimore Gas and Electric Co. Eighty-seven miles of brass tubes will be threaded through 169,532 holes in the condenser. The quarter of a million dollar drill was purchased by Worthington Corporation's Harrison Division and was built by Moline Tool Company. The electronically controlled machine can drill more than 2,000 holes per hour in ¾-inch thick metal plates and in an endless variety of patterns. The holes it drills position the thousands of water tubes in large condensers such as the one illustrated. The drill is controlled by perforated tape. Instructions from the tape are relayed to banks of automatic stepping switches which control drilling patterns, and position the machine on a two-directional axis. Memory circuits arranged on a nearby control panel feed additional instructions to the electronic brain.

G. G. KNICKERBOCKER and W. B. KOUWENHOVEN

Electrical techniques and the heart in health and disease

Some interesting examples are presented of electrical measuring techniques in three principal areas of medical science: basic physiology; diagnosis of disease; and treatment of disease. Intracellular recordings, electrocardiography, flow-recording techniques, pacemaking, and defibrillation are among the specific methods discussed.

In an age of extreme specialization, the electrical engineer has come to see his discipline applied in many remote fields. Not the least of these are the fields of medicine and biology. Electrical measurements in the hands of the physician are now an important tool for understanding the functioning of the human body, and diagnosis and treatment of disease. With this intermingling of the disciplines has come the necessity of a common vocabulary for the engineer and the physician. Of interest to many electrical engineers are the applications of electrical measuring techniques to medicine. This article presents some examples of employing electrical measuring techniques which may lead to some general principles of biological measurements.

For purposes of discussion, the methods of biological measurement that we shall pursue fall into three broad categories. The first is the use of electrical measurements designed for the purpose of performing basic physiological studies. These are employed to give a basic understanding of the nature of the system, its behavior in health and disease, and its response to external stimuli. The second area concerns itself with the application of techniques to the field of diagnosis. Here it is important by various probing techniques to ascertain whether a state of disease or malfunction exists, and to localize this disorder in a particular organ or a particular area of an organ in the body. Third, treatment of disease is often carried out with the aid of electricity. While therapy seemingly does not require sophisticated measuring techniques, nevertheless there is a requisite amount of monitoring necessary to measure the results of the therapy. In some instances treatment may be applied directly through electrical methods.

It is impossible within the limits of this article to investigate fully the techniques that may be applied in the fields of medicine and biology but, as an example which includes many facets of medical study, we have chosen for discussion several of the techniques of measurement that may be applied to the heart. One reason for this is that the basic behavior of the heart as an organ of the human body is relatively well appreciated by the nonmedical public. Moreover, work in this field has brought us into closer contact with the problems associated with instrumentation for cardiac studies than for other organic or biological systems.

NATURE OF HEART ACTIVITY

To establish a firm foundation for an understanding of the techniques which will be discussed later, we shall begin with some of the characteristics and the nature of the normally beating heart. The heart is a 4-chambered pump, in reality two 2-chambered pumps in parallel and pumping almost synchronously. It is responsible for moving fluid—the blood—from the body to the lungs, where the blood receives oxygen and gives off waste products (principally carbon dioxide); then the blood is carried from the lungs to all tissues and organs of the body, to supply these tissues with nourishing oxygen in exchange for waste products. These chambers perform their pumping action by reduction of their internal volumes through shortening of the contractile elements of the chamber walls. The two parallel pumps are at the right side of the heart, pumping to the lungs; and at the left side, pumping to the body.

The two principal chambers of each pump are the auricles, or the entry way to the heart, and the ventricles. The auricles, while performing some contrac-

Essentially full text of paper CP61-943, presented at the AIEE Pacific General Meeting, Salt Lake City, Utah, Aug. 23-25, 1961. Recommended for publication by the AIEE Special Instruments and Auxiliary Apparatus Committee.

G. G. Knickerbocker, Associate Member AIEE, and W. B. Kouwenhoven, Fellow AIEE, are with the Department of Surgery, School of Medicine, Johns Hopkins University, Baltimore, Md.

The authors gratefully acknowledge the support received from the Edison Electric Institute, National Institutes of Health, and Heart Association of Maryland.

tion, contribute little to the forward energy of the blood. The ventricles impart essentially all the energy and motion. These chambers contract approximately once a second and eject a few hundred cubic centimeters for each cycle. The heart, being a vigorous, active organ, requires nourishment and is richly endowed with a blood supply utilizing an appreciable quantity of the output of each cycle. A unique and efficient set of valves within the heart and the vessels leading from the heart insure that the flow of blood is predominantly, if not totally, in the forward direction.

The nature of the contractive elements of this pump should be of much interest to mechanical and electrical engineers. Schematically, and only schematically, the basic muscle fiber of the heart can be considered a coaxial cylinder with a thin insulating outer sheath and a highly complex interior. Electrically, the interior can be thought of as a conducting fluid, isolated from the exterior of the cell by the cylindrical sheath or membrane. Mechanically, this rather simple internal conductor is found to be a highly complex protein chain exhibiting characteristics of acute change of physical dimensions when stimulated.

Electrically, the cell at rest exhibits a potential difference of approximately 90 millivolts between the interior and the exterior of the cell, with the interior relatively negative with respect to the outside. Upon stimulation, this potential drops markedly and rapidly to zero (Fig. 1 shows the depolarization) and, in fact, goes somewhat positive with respect to the outside of the cell, then slowly recharges itself (repolarization), eventually regaining the so-called resting potential of approximately 90 millivolts. Approximately concurrent with this electric potential change is the activation of the mechanical contractile protein of the heart which results in a shortening, and then relaxation, of this co-axial fiber. This cycle

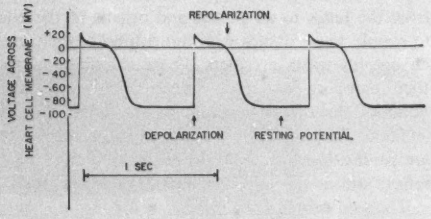


Fig. 1. Action potential of a heart cell

is repeated about 70 times a minute, 60 minutes in the hour, 24 hours a day, throughout the life of the individual.

Abnormalities in the electrical behavior of the cell, as well as modification of the behavior of the contractile elements within the cell, can lead to inefficient or improper action of this organ as well as deformation of the gross structure of the heart. All of these conditions can lead to impairment of heart function with the resultant deficiency in the form of reduced supply of nourishing oxygenated blood to the rest of the body and organs. Localization of these inferior or improperly operating areas is done by many means, not the least of which call for the use of various forms of electric apparatus. Treatment of these diseased areas involves approaching the heart either directly (by surgically correcting the defect) or indirectly through the use of drugs. The effectiveness of all these techniques is monitored by some of the same electrical measurements that were used to diagnose the disorder. With this brief background we can observe specific examples of techniques used for the study of the healthy and the diseased heart.

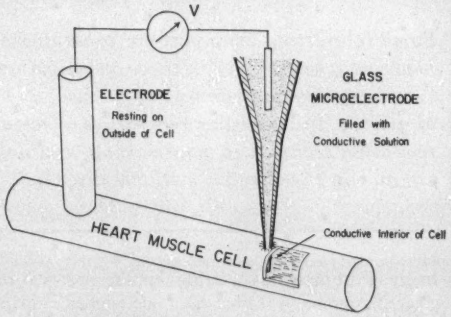


Fig. 2. Schematic representation of heart muscle cell with microelectrode for intracellular potential measurements

BASIC PHYSIOLOGICAL STUDIES

To understand the normal as well as the diseased heart, basic studies of its fundamental nature must be made. Quite commonly, studies are conducted of some of the lower animal species where direct visual correlation can be made with the observed measurements on the heart. Familiarity with the proper function of the heart is attained by study of the structure of its minutest elements and their electrical, mechanical, and general physiological behavior. The dynamics of the organ can be studied at this level as well as its response to external stimuli.

An interesting study in the structure of the heart has been carried out through the use of what has come to be known as direct intracellular recordings. By this fascinating technique, it is possible to enter the cell electrically and measure the properties of this coaxial cylinder.[1] The cell, the basic element of the heart, is an extremely minute unit, somewhat less than 10 microns in diameter and probably no more than a few hundred microns long. The heart is not a simple collection of cylinders but an intricate interweaving of these fundamental units. Current practice among biological investigators for studying the intra-

cellular potentials in cardiac fibers has been to introduce into the interior of the cell a slender tapered glass tube, only ½ micron in diameter at its tip.

When filled with conductive solution, usually strong potassium chloride, the glass tubing becomes an electrode in contact with the potential within the cell; see Fig. 2. Because of the characteristics of the conductive solution within the cell, quite stringent requirements are placed on the amplifiers used to observe the time-varying potential V, as the ability of these cells to supply current is severely limited by their small volume. The input impedance of such an amplifier must be in excess of 10^{10} ohms with grid current less than 10^{-12} ampere. These amplifiers are now designed with compensating feedback to cancel effects of input capacitance, in order that the fast rise times of the stimulated cell can be accurately recorded from the high-impedance source.[2] Fig. 1 is an artist's reconstruction of such a recording from the interior of a cell.

The network of cells in the heart is not synchronously activated but, more as in a row of standing dominoes, one cell appears to activate the next. It has been known for many years that there is specific delaying tissue in the chain, most prominently in the region which relays stimuli from the auricles to the ventricles. To study the activation process, some investigators have introduced a needle with a distributed system of electrodes into the muscular mass of the inner and outer walls of the heart.[3] Displaying simultaneously on an oscilloscope the signals seen at each of the many electrode pairs makes possible determining the relative times of stimulation of the muscle and fibers lying next to each electrode pair. It is then possible to map the spread of the wave of depolarization through the heart and come to a better understanding of the way that the wave of contraction of the heart is distributed. It should be obvious that the diseased state can cause abnormalities in this distribution system and lead to inefficient contraction patterns.

Many techniques have been developed for understanding more completely the work output of the heart. Instrumentation for the determination of pressures throughout the chambers of the heart and for the measurement of flow is necessary so that more accurate information about the hemodynamics of a contracting heart may be gained. Currently in use for the recording of pressures within the heart and within the blood vessels of the body are strain-gauge pressure transducers which, in response to varying pressures, modulate conventional carrier preamplifiers so that pressure contours may be observed.

Recordings of blood flow must be coupled, of course, with pressure measurements. Adequate techniques for the recording of phasic flow have eluded investigators to a somewhat greater extent than some of the previously mentioned techniques. Severe limitations are placed upon flow-indicating devices because it is necessary for them to measure flow accurately without compromising the size and flexibility of the blood vessel wall. Also, they must not cause damage to the blood. The cells of the blood are extremely sensitive to any mechanical interference and will break down with small provocation.

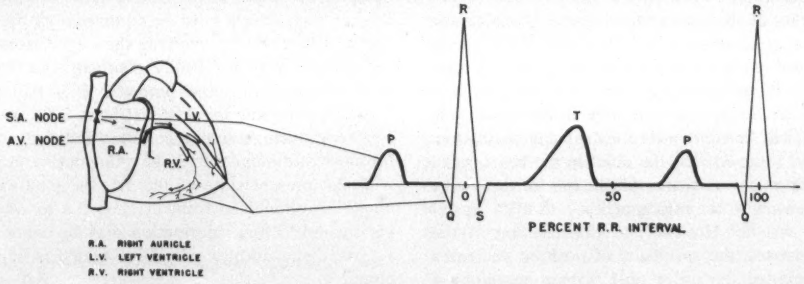


Fig. 3. The components of the ECG and the sites of their origin in the heart

Among the various ways of measuring flow, two currently used techniques seem to hold promise. The first, the electromagnetic flow meter, identical in principle with that which may be familiar to engineers in the field of nuclear instrumentation, relies upon the ability of a conductive fluid moving through a magnetic field to generate a potential proportional to the velocity. Small probes have been developed, containing coil and core for setting up the magnetic field and the electrodes, which, when intimate with the blood vessel wall, detect the voltage induced by flow in the blood vessel. Such probes can be implanted around some of the larger vessels for studying the flow in an anesthetized animal. Where the bulk of the excitation coil and core become prohibitive, flow measurements employing the same principles have been made in the smaller vessel, by implanting electrodes on the vessel. The animal is then placed in an externally generated magnetic field.[4]

The second principle of flow measurement is the ultrasonic flow meter. With two ultrasonic trans-

ducers along the blood vessel, it is possible to introduce ultrasound into the stream in either direction.[5] The phase difference between propagation upstream and downstream is proportional to velocity. The principal difficulty in this technique seems to center around the problem of efficiently coupling energy into and out of the vessel without distorting the flow pattern.

The ability of the heart to respond to stimuli, whether electrical, mechanical, chemical, or thermal, is well known. While mechanical and thermal stimuli have been relatively unexploited, the response of the heart to electrical stimulation of practically every size and shape has been studied. Of particular practical interest are studies which are aimed at determining the vulnerability of the heart to 60-cycle electric shocks. The heart can be thrown into a state known as ventricular fibrillation from shocks of certain magnitudes and durations. In ventricular fibrillation, all fibers of the ventricles contract independently and no blood is moved. The result is usually fatal. It is therefore of interest to know what the severity of the shock must be to cause the heart to go into this state of fibrillation.

By means of studies on experimental animals some interesting conclusions can be reached. If the heart is subjected to a short electric shock of 60-cycle current, of the order of a few cycles in duration, and the shock occurs at a certain point in the heart cycle the heart will be thrown into ventricular fibrillation. It is found (Fig. 3) that the point in the heart cycle, which will cause ventricular fibrillation for these very short shocks is in the region of 20% to 40% as defined by Fig. 3.[6] However, as the duration of the shock increases, the specificity of position decreases until shocks of the order of 1 second in duration may elicit ventricular fibrillation independent of their point of onset in the heart cycle.

In general, fibrillation is caused by lower currents as duration of the shock increases. Experiments were carried out by delivering to the animal a shock of measured duration and measuring the magnitude of the shock during the flow of current. The action upon the heart was monitored by observing the electrocardiogram (ECG), a recording of the electric potentials developed by the heart as seen on the body surface.

DIAGNOSIS

The diagnosis of diseased states presents the physician with something the same type of problem as the engineer with the proverbial "black box." He must find out what is going on inside without being able to see inside and, moreover, he is not able to take it apart. Several techniques come to mind that may be of interest; the first, the most obvious, uses the electrocardiogram; see Fig. 3.

As described earlier, the individual cells of the heart each have an electric potential associated with them, and this voltage has a predictable time variation when stimulated. It is fairly well established that this potential change results from the transference of certain chemical ions and nutrients across the cell membrane, and changes in the membrane during excitation. As a result of orderly excitation throughout the entire musculature of the heart, the net effect, from a distance, is that the heart appears as a collection of time-varying current dipoles. Being a 3-dimensional collection of dipoles in a volume conductor (the body), there is a time-varying potential field throughout the volume conductor and on the surface. The ECG is the recording of the time variations of these potentials.

Since there is a spatial distribution of potential, the choice of placement of electrode pairs determines which "view" of the heart that particular electrocardiographic recording represents. The magnitude of electrocardiographic potentials on the surface of the body are of the order of a few millivolts. Electrical contact with the body is usually made with flat metallic electrodes of a few square centimeters of area. Since tissue impedance includes frequency-dependent components, which reside chiefly in the surface layers of skin, their effects must be minimized by the use of special jellies which overcome the impedances in the superficial layers and insure good contact. To minimize loading,[7] the input impedance of the electrocardiographic unit should be at least 100,000 ohms. For reproducing these waveforms faithfully enough for most cardiologists to make a diagnosis compatible with the present state of the art, the bandwidth of amplifiers should be from at least 0.8 to 80 cycles per second.[8] More information may be contained in a wider bandwidth, a possibility which is being explored.[9]

Fig. 3 shows the basic components of the ECG with the associated regions of the heart where these potentials arise. Following the nomenclature laid down by Einthoven, the "father of electrocardiography," the P wave results from excitation arising in the pacemaker or "ticking clock" of the heart, and the spread of excitation over the auricles. A short period occurs when, preceding the next big complex of potential, no electrical activity is apparent. During this time the stimuli from the auricles pass through the delaying tissue, mentioned previously, on their way to the ventricles. As excitation spreads quickly through the wall between the two large ventricles of the heart and out to the muscular outer walls of the ventricles, the large QRS is generated.

During this period, all the fibers of the ventricles have depolarized or discharged themselves. As recharging or repolarization of these ventricular fibers takes place, the T wave is formed. The repolarization of the auricles is manifest in such a small signal that it is masked by the QRS complex and is not seen. A resting period ensues until the next P wave starts the cycle over again. All this takes place in slightly less

than a second in normal individuals. Mechanical action of the heart lags the electrical activity slightly.

From changes in the shape of the basic electrocardiographic waveforms, changes of the conduction pathways can be inferred. In this way the physician can detect the presence of cardiac disease. Fig. 4 compares a relatively normal ECG with an abnormal recording. At the point marked *1* there is a completely bizarre waveform, probably associated with a "skipped beat," and in the region *2*, differences in waveform can be detected. Changes of this type are significant to the cardiologist.

Research in the field of electrocardiography lies predominantly in two areas. The first is display systems. Inasmuch as the body is 3-dimensional, the view of the heart which the cardiologist has is dependent upon the choice of electrode positions. By taking the potentials from a set of orthogonal elec-

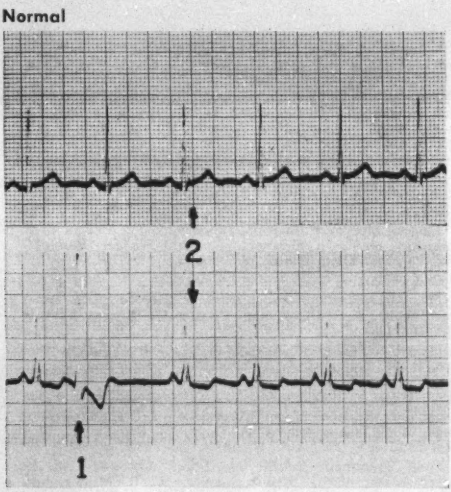


Fig. 4. Comparison of normal and abnormal ECG's

trode pairs and displaying them on the mutually perpendicular axes of an oscilloscope, the projection of this dipole cluster on a plane can be observed. Further sophistication can be reached by adding another set of electrodes such as the above, slightly displaced spatially, and displaying each set on a separate oscilloscope face, with suitable optics to provide a stereoscopic view of the projection of the electrical activity of the heart. These techniques constitute a small portion of the field of vector cardiography.[10,11]

A second area of research interest in electrocardiography, and a field of vast potential, is the utilization of computers to arrive at an interpretation of the ECG. The many combinations of waveform variations lend themselves to the rapid statistical analysis that the computer is so capable of handling. Little can be said about this field except to introduce it for the reader's consideration.

Another diagnostic tool is the ballistocardiogram, a recording of the forces developed by the heart during contraction and ejection of the blood.[12] If a person lies on a suitably suspended bed, these forces result in accelerations of the bed which can be detected by sensitive accelerometers. The accelerations can be displayed, along with the resulting velocities and displacements derived from repeated integrations. As this field is developed, much information will become available to help in diagnosing cardiac problems.

TREATMENT

The use of electricity in the treatment of disease lies predominently in monitoring the effectiveness of the therapy. This primarily involves methods described earlier. However, two electrical methods of treatment have achieved some degree of popularity. They are cardiac pacemaking and electrical countershock for defibrillation.

Some diseases of conductive heart tissue or abnormal distribution of stimuli arising within the heart affect its basic rhythm and the heart beats irregularly and/or slowly, often not putting out enough blood to support life at a satisfactory level. Since the heart is responsive to external signals, short rectangular pulses or approximations thereof, delivered to electrodes in the muscle of the ventricle, will often elicit effective contractions of these chambers.[13] As long as the rate is greater than the intrinsic rate of the heart, pacemaking, as this is called, can be continued effectively. It is equivalent to synchronization of a relaxation oscillator at a rate higher than its natural frequency.

For chronic conduction problems, it is possible to implant a stainless-steel wire electrode in the heart and drive the heart from a stimulator outside the body. This is particularly adaptable to the postoperative recovery period, where as a result of surgical repair of heart defects conduction problems may arise. However, for long-term use some difficulties appear. The human body does not tolerate wires entering or leaving the body through holes in the skin, and healing at the point of entry is slowed or does not take place. For these cases, techniques for imbedding encapsulated long-life stimulators within the body are beginning to reach fruition.[14]

The energy requirements for pacemaking are reasonably modest. A pulse of a few (usually less than 5) milliseconds' duration and of a few milliamperes in amplitude, repeating 70 times a minute, is an effective pacemaker pulse. Often these units are designed around a basic blocking oscillator circuit and can be made quite compact. Pacemakers are being developed for implantation with expected life of about 5 years.

In some emergency situations, it is possible to use a much stronger impulse and deliver the pulse to electrodes on the chest wall. Of the total current that flows, some will go through the heart and result in stimulation. Long-term use of this approach, in the fully conscious patient, is severely limited because of the pain of the repetitive electric shock.

We have discussed the state of ventricular fibrillation. This may arise as a result of electrical accident, adverse reaction to anesthetics, or some forms of heart attack. During this event the heart is not pumping any blood and death is rapidly setting in. The heart in this state is completely unresponsive to any type of pacemaker pulse, as described. To return it to some state of effective organized activity, these bundles must all be uniformly stopped or brought to the same state. A massive electric current sent through the heart has proved effective.[15] This can be done either by placing a pair of small electrodes directly on the heart, and sending a 60-cycle current of an ampere or so through it for about 0.1 second, or larger electrodes about 3 inches in diameter can be placed on the chest wall and enough current delivered to contract the heart fully. The normal adult requires a current of about 5 amperes, flowing for 0.25 second, to do the job effectively; this requires 440 volts. Many hearts have been defibrillated and it is this technique that offers some hope of help to the victims of sudden heart attack that would otherwise be immediately fatal.

A broad spectrum of electrical techniques used in the study and treatment of the heart have been discussed rather superficially. These do not exhaust the possibilities within the cardiac specialty. Moreover, they represent only a small fraction of the techniques available to all the biological and medical specialties. It is hoped that the methods described have been of interest to the electrical engineer; perhaps some will be stimulated to delve into these problems further. In this way the engineer and the biological scientist can meld their separate disciplines for the benefit of mankind.

REFERENCES

1. Electrophysiology of the Heart (book), B. F. Hoffman, P. R. Cranefield. McGraw-Hill Book Co., Inc., New York, N. Y., 1960, Chap. 1.

2. Measurement of Bioelectric Potentials with Microelectrodes and Neutralized Input Capacity Amplifiers, E. Amatniek. *Transactions*, Professional Group on Medical Electronics, Institute of Radio Engineers, New York, N. Y., vol. PGME-10, March 1958, p. 3.

3. Ventricular Depolarization and the Genesis of the QRS, A. M. Scher, A. C. Young. *Annals of the New York Academy of Sciences*, vol. 65, 1957, p. 768.

4. Electromagnetic Blood Flow Meters, A. Kolin. *Science*, Washington, D. C., vol. 139, no. 3382, Oct. 23, 1959, p. 1088.

5. Ultrasound in Biology and Medicine (book), E. Kelly (editor). American Institute of Biological Sciences, Washington, D. C., 1957, p. 165.

6. A-C Shocks of Varying Parameters Affecting the Heart, W. B. Kouwenhoven, G. G. Knickerbocker, R. W. Chesnut, W. R. Milnor, D. J. Sass. AIEE *Transactions*, pt. I *(Communication and Electronics)*, vol. 78, May 1959, p. 163.

7. Medical Electronics (book), C. N. Smyth (editor). Iliffe and Sons, Ltd., London, 1960, p. 91. *Proceedings*, Second International Conference on Medical Electronics, Paris, France, June 24-27, 1949.

8. Requirements in Equipment and Techniques for Vectorcardiography, J. A. Cronvich, G. E. Burch, and J. A. Abildskov. *Circulation*, New York, N. Y., vol. 8, no. 6, Dec. 1953, p. 914.

9. The Effect of the Frequency Response of Electrocardiographs on the Form of Electrocardiograms and Vectorcardiograms, A. J. Kerwin. *Circulation*, vol. 8, no. 1, July 1953, p. 98.

10. Spatial Electrocardiography (book), G. E. Burch, J. A. Abildskov, and J. A. Cronvich. Lea and Febiger, Philadelphia, Pa., 1963, Chap. 2 and 3.

11. *Ibid.*, Chap. 5

12. The Ballistocardiogram: A Dynamic Record of the Heart Beat (book), J. R. Braunstein. Charles C. Thomas, Springfield, Ill., 1953.

13. Long Term Electric Pacemakers for Stokes-Adams Disease, P. M. Zoll and A. J. Linenthal. *Circulation*, vol. 22, no. 3, Sept. 1960, p. 341.

14. A Transistorized, Self-Contained, Implantable Pacemaker for the Long-Term Correction of Complete Heart Block, W. M. Chardack, A. A. Gage, W. Greatbatch. *Surgery*, St. Louis, Mo., vol. 48, no. 4, Oct. 1960, p. 643.

15. Field Treatment in Electric Shock Cases II, W. B. Kouwenhoven, G. G. Knickerbocker, W. R. Milnor, and J. R. Jude. *Electrical Engineering*, vol. 79, no. 6, June 1960, p. 500.

Space-Etched Hieroglyph

View of half-size crystal can relay subjected to to the extreme cold that space vehicles encounter when orbiting in the earth's shadow. This earth-made preview of space environment was re-enacted at −65 C in Leach Corporation laboratories in Los Angeles, Cal. Leach supplied 116 relays to help United States astronauts actuate power switching controls in Mercury capsules. Single failure might have meant failure of entire mission; hence rigid tests to insure near-perfect reliability. Relay itself, readily identified by diagram, is no bigger than a dime. Photo is from Leach motion picture "Half-Size Relay—Full-Size Results" produced for design engineers and scientists.

S. LEVINE

Large-scale on-line data processing systems

On-line data processing systems are used for large-scale operations such as transportation reservations, bank transactions, and inventory control. Experience has shown that a system-oriented rather than a hardware-oriented approach is required in their design. Over-all characteristics and design techniques are described briefly in this article.

On-line data processing systems have been developed for industrial and business problems which may be classed as inventory control of products with regional, nation-wide, or even world-wide distribution and demand. Examples of applications requiring systems of this type include the control and reservation of passenger or cargo space in the transportation industry; the handling of deposits and withdrawals in savings banks with many branches; processing, distributing, and retrieval of information concerning stock transactions and quotations; and the control of inventory for large-scale manufacturing and distributing organizations, as well as for government and military organizations.

All of the systems exhibit these common characteristics, which determine the requirements for an on-line system:

1. Widespread geographical dispersement of customers or subscribers who compete for access to the processing equipment and inventory and thus can develop queues during heavy load periods.
2. The need for very fast response times to queries by agents or subscribers operating input devices, to reduce the number of agents and input devices required in peak periods, and to minimize the time required to process a customer, who may be standing in a line in front of a counter or teller's window or connected by phone to the agent.

Essentially full text of paper 61-732, presented at the AIEE Summer General Meeting, Ithaca, N. Y., June 18-23, 1961. Recommended for publication by the AIEE Computing Devices Committee. Scheduled for publication in AIEE *Communication and Electronics*, Nov. 1961.

S. Levine, Member AIEE, is with the Teleregister Corporation, Stamford, Conn.

SYSTEM REQUIREMENTS

Experience in the design and analysis of on-line systems with the general characteristics listed above has emphasized the following important requirements, which are particularly applicable to the airline transportation industry:

1. The system must be designed not only for fast response and access to input–output devices over a wide geographic area, but also for operation on a continuous basis (24 hours a day) with sufficient reliability and capacity to handle peak traffic.
2. It must include facilities to assure accuracy of data and the proper audit of all actions taken.
3. It must have inherent capability of expansion to meet the expanding volume of traffic for a period of at least five to ten years after it is placed in operation.

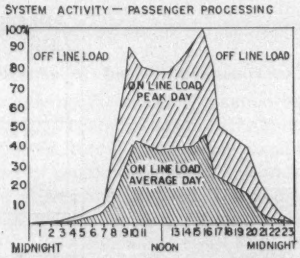


Fig. 1. Peak activity curves for airline passenger reservations

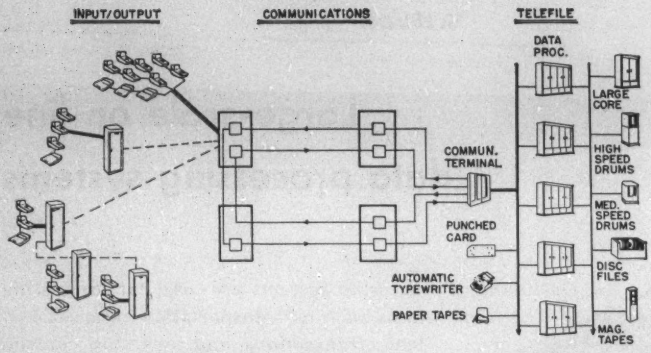


Fig. 2. Over-all system block diagram

4. It must be flexible, to permit changes in program as a result of changes in operating procedures.

5. It must be flexible and expandable, to permit integration of additional functions, which may not yet be fully defined, by means of added equipment or program changes as required. It must permit additions of this nature without shutdown of those portions needed to maintain the traffic load.

6. It must be designed so that a portion may be taken out of service for maintenance without upsetting its capacity to handle normal load.

SYSTEM DESIGN APPROACH

Previously, equipment and system design was tailored to one or two aspects of the problem for which specific requirements had been defined. Special-purpose wired program computers were used and extended into complete integrated systems by means of special communications systems.[1] However, in view of the requirements just outlined, it has become apparent that the basic philosophy in approaching the design of on-line systems can no longer be based upon the study and solution of only those aspects of the problem which appear to have the most immediate and urgent justification. An analysis should be made of all possible aspects of the problem on an integrated system basis.

The requirements and interrelationships of all functions should be defined, at least in general terms, and from this, those areas which justify most immediate mechanization as part of an over-all plan of evolution into a complete system can be established.

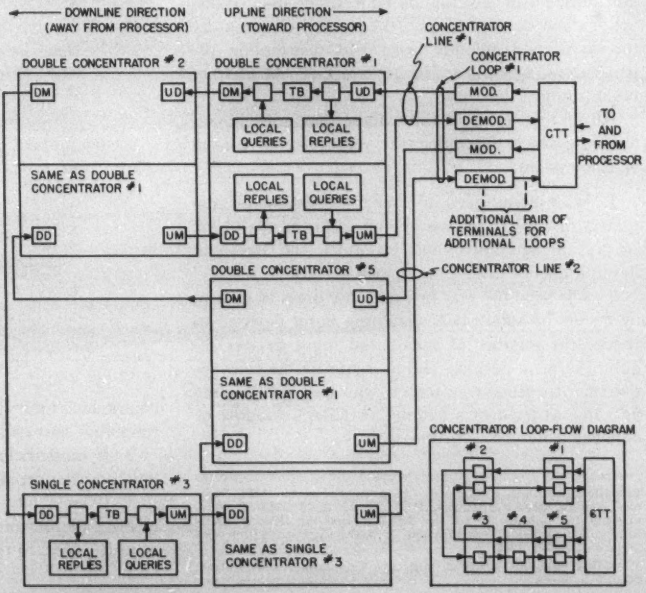


Fig. 3. Communication system block diagram

DD = Down-line demodulator
DM = Down-line modulator
UD = Up-line demodulator
UM = Up-line modulator
TB = Transfer buffer

This approach is considered necessary to assure that in the design of systems for solving specific problems, sufficient flexibility is included to permit expansion and addition of equipment and functions without rapid obsolescence of the initial equipment.

Design Considerations

The handling of airline reservations imposes a peak demand requirement on the system. Fig. 1 illustrates the variations in traffic for a typical airline over a 24-hour period. This is shown both for an average day and a peak day. From this diagram it is clear that if rapid response times are to be maintained, the system must be designed for the peak load requirements.

This peak for many airlines represents only 1% of the total traffic handled by the airlines in a year and may not occur for more than a total of 25 to 50 hours during the year. Further, within any 24-hour day, the peak capacity for that day is required for no more than 6 to 8 hours.

Response time, as well as traffic volume, plays an important part in establishing the peak requirement. The nature of a reservations operation is such that queries and responses for availability data and inventory actions should be processed in a system-wide average of 1 or 2 seconds, and transactions involving passenger records in an average of 5 to 10 seconds. These requirements are imposed by the fact that during peak periods an agent must be able to process a telephone inquiry in less than 2 minutes. Since each telephone call results in an average of five processor calls, each of which requires set-up time and conversation time with the consumer, a response time per call longer than an average of 5 to 10 seconds would affect the efficiency of an agent adversely. Thus, a system designed for this peak on-line requirement can have inherent capacity to handle all related off-line processing and updating requirements, as well as many other functions. A system of this type will be relatively high in cost; hence economic justification may force inclusion of many related or even unrelated off-line requirements. (Off-line functions are defined as those which do not require immediate response.)

Traffic Analysis

Analysis of requirements for an airline passenger control system may be shown as a pattern of traffic generated at large numbers of offices (reservation offices, city ticket offices, and airport ticket offices). For a typical large nation-wide trunk airline, there may be as many as 100 to 200 offices in 50 or 70 cities. The number of input–output devices (agent or subscriber inquiry sets) required for a complete system may be 1,000 to 2,000, with quantities increasing because of increasing traffic at rates of 5 to 10 per cent per year. The total traffic, if handled by a central processor, ranges from 5 to 50 calls per second during peak periods, with messages averaging 100 to 400 bits. The range of message rates is a function of the size of the airline and the year considered as well as the functions included. A total processing load of this type requires a wide range of processor capability and justifies the use of a range of data communication channels ranging from 75 bits per second to 1,000 or 2,000 bits per second.

Response Time

The response time requirements are determined by the waiting time which can be tolerated by an agent and, in turn, by the customer, during peak periods. For an efficient and economical balance between equipment cost, agent cost, and customer satisfaction, response times for an airline inquiry ideally should be from 1 to 5 seconds, measured from the time the agent requests access to the communication system and processor to the time the response starts to be received on his output display.

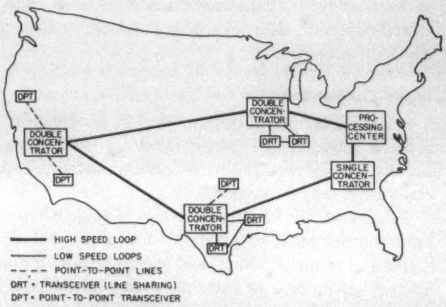


Fig. 4. Typical geographical layout for communication system

Centralization vs. Decentralization

In considering the design of a nation-wide system, the problem of centralization or decentralization must be considered. If traffic is distributed uniformly or in a number of concentrated areas, a decentralized system may appear to be justified. This approach would require a number of data processing centers with relatively short communications lines radiating as tributaries from each processor site. The problem of integrating these processors introduces the need for high-speed tie lines to interconnect them with a central processor.

Analysis shows that, from a general point of view, the centralized approach is economical and permits maximum control. Each agent set acts independently, but control is centralized. Since the traffic and response time requirements of the airlines are approaching levels which require high-speed lines (1,000 bits per second), centralization can achieve the tight control required.

OVER-ALL SYSTEM DESIGN

A systems approach has been developed by the Teleregister Corporation to meet the previously mentioned design criteria. The design is based upon a building-block technique, which is expected to permit growth and expansion of the system in an economical fashion to take care of the growth of business, to permit addition of new devices for the input and output of data, and to extend the storage and processing capability as needs develop. This technique permits installation of only those portions of the system required initially and expansion at the rate actually experienced, rather than requiring that the capacity for the full life of the system be provided initially. Included are all elements of an integrated processing system (see Fig. 2), such as input–output devices of various types, data communication links, and a stored-program data processing system called the Telefile* processor.

Input–Output Devices

A universal input-output device is difficult to achieve economically. Since many of these devices usually will be required in an on-line system, a special design may be justified.

In general, the requirements are that each type of input–output must be simple to use, must include a method of input checking, and should require a minimum of set-up time to enter the data into the system.

Some flexibility in design must be included, such as space for additional keys in a keyboard entry device,

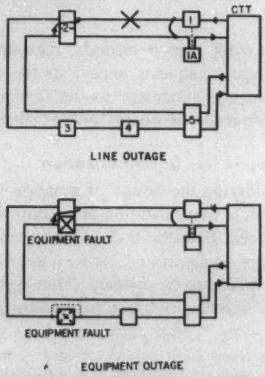


Fig. 5. Communication fall-back procedures

space for additional columns, or variability in letters or numerals in each column in a printing device.

A measure of modular design can be achieved, even in the input–output position, by design of each functional assembly as a compact subassembly which is capable of being installed and combined with other assemblies in a common plastic housing. When made in medium to large quantities, these housings can be made cheap enough to be discarded when an additional device is added to the input position. Typical subassemblies may be a keyboard numeric array, a card reader, a line printer module, or an alphanumeric or alphabetic keyboard. An airline reservation input keyboard, display, and coded card is shown in the title illustration.

Where traffic requirements are heavy, input–output devices in an on-line system are often grouped together in common locations. For economy in use of communications lines, equipment is provided to interconnect and allot access to each agent and to provide necessary buffering and decoding to match the input–output device with the communication system.

Communications System Design

The communications system design (Fig. 3) is based upon a flexible equipment configuration to provide the capacity, response time, and fall-back justified for each reservations office. The large traffic generating centers are connected by high-speed (1,000-bit-per-second) full duplex voice-band data channels to the data processor. Typical communications system geography is illustrated in Fig. 4. A number of these large, remote centers, called concentrators, are connected in a single high-speed loop to minimize cost. A full duplex loop arrangement is employed, to provide the reliability required for these heavy traffic centers. The loop arrangement provides two paths for reaching the processor and includes signaling facilities for monitoring the line-for-line or equipment failures, and for centralized control of the loop arrangement to bypass or isolate line sections in which the equipment or line has failed or become excessively noisy; see Fig. 5. More details of this equipment are discussed elsewhere.[2,3] Further reliability may be achieved by redundancy in the concentrator stations. Dual units are provided with means for automatic switchover. The relatively fixed message lengths of the system permit use of the free flow type system. A transfer magnetic core buffer, with capacity sufficient to accommodate the longest message, is used at each concentrator to permit injection of single messages without endangering a message already in the line. This type of system permits fast responses or greater traffic-handling capacity than a selective calling type of system, since capacity of the line is not affected by roll-call time. Expansion of the system is accomplished by the addition of stations or loops.

Data Processing Equipment

A centralized system imposes high peak traffic rate requirements, high reliability requirements, and large random access storage requirements on the data processing center. Justification for a centralized system can be demonstrated for a large major airline in the savings in maintenance cost, operating costs, and

*Trademark, The Teleregister Corporation.

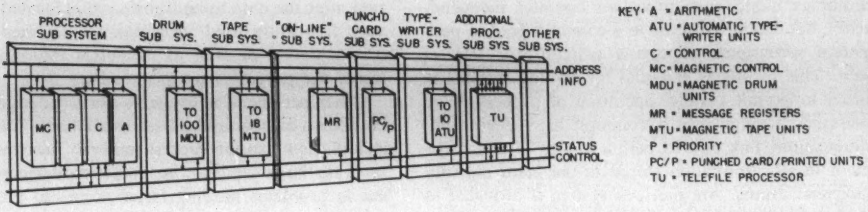


Fig. 6. System block diagram. Telefile data processor

equipment cost. A system with four processor locations requires two processors at each site for reliability and almost complete duplication of the storage at each location. A central system even with the same basic processors would require only four or five locations, and would provide better traffic handling capacity and reliability. This is illustrated by queuing analysis. Multiple processors, when connected in tandem as multiple servers, can be loaded more effectively for the same delay or waiting time. A single processor can be loaded to 66 per cent as compared to 88 per cent per unit for a 3-processor system. Thus, a 3-processor system operated in parallel provides capacity equivalent to four separate processors.

Similarly, the reliability of a multiprocessor system is improved to a point where the probability that all three of a group of processors are out simultaneously is almost negligible. For example, a single processor system with up time of 97 per cent can be improved theoretically to an up time of 99.9 per cent by going to a 2-processor system; the third processor increases system reliability to better than 99.99 per cent.

Other factors which have influenced the design of the processor system include the problem of obtaining optimum balance between speed and access time. For the on-line problem with large random access storage, the system is generally access-limited with currently available storage techniques. The average on-line call uses more than half the call time for access to storage.

A 3-processor installation should provide adequate reliability for almost any application. The effective data-handling rate of the processor system should be designed so that two processors can handle the system peak traffic, with the third processor serving as fall-back and for other functions. With a multiprocessor system, an increase in data-handling speed can be obtained for a small increase in cost. This increase in processing rate need not be achieved by increasing the basic speed of the processor. Reduction in effective access time to storage by use of parallel access paths can provide the improvement desired and avoid the more costly approach of a new or modified basic processor design for each application.

Thus, it appears that in considering all of these factors, a system which can be set up in centralized multiprocessor arrangements represents the best approach to meeting the system criteria.

Processor Design

A new stored-program general-purpose data processor using solid-state components has been designed and constructed to meet the requirements. This Telefile processor includes a number of unique features not found in processors currently in use; see Fig. 4.

The central computer and control elements are organized around a relatively small magnetic core, with a working storage of 10,000 or 16,000 decimal digits. Operation of the computer is sequential by character at a rate of 16 microseconds per character.

Any single character in the core memory can be addressed, and the word length is variable from one character to 100 characters or even up to the full size of the core memory by use of end sentinels. The central processor also serves as a control and switching center to permit communication over a common 4-bus network with many different peripheral subsystems. The basic structure permits interconnection to up to 29 subsystems, each of which can operate independently. Communication to and from the processor is controlled by a priority control system.

This structure permits multiplexed operation and overlapping of computer internal operations with subsystem operation, such as location and selection of information on magnetic drums and tapes for subsequent transfer to and from the central working memory, or transfer of a single character every 100 milliseconds from a number of slow-speed input–output subsystems, such as paper-tape punches and electric typewriters.

Communications to remote on-line input–output devices over communication channels is also accomplished through one or more peripheral subsystem channels through buffer register subsystems. Subsystems such as magnetic drums, magnetic tapes, magnetic disks, electric typewriters, and tape punches and readers, do not include buffer registers; however, by means of a small control register, information to and from sections of the core memory can be addressed and transferred.

Further expansion of the Telefile processor system can be accomplished by additional modules which permit two processors to be operated in either a dual or duplex mode. In dual mode, both processors operate simultaneously on the same data fed from a common input–output subsystem. Dual operation permits cross check of each operation. In a duplex or

multiplex mode, each processor operates independently, but can have access to a common pool of peripheral subsystems through a switching or selector unit. This facility is essential for on-line systems in order to permit parallel operation of processors on messages arriving over a common high-speed communications link and to permit access of any processor to all information stored in the main memory magnetic drums. An interlock system is provided to exclude a second processor from access to a particular section of the drum memory, or to a particular magnetic tape or punched tape unit, until the first processor has completed its operation and released the subsystem.

Although queuing interference does occur, the amount is relatively small because in on-line operation a large portion of the operation are inquiries to information stored on magnetic drums and only one access is required to the information, after which it is transferred to the core memory for subsequent operations.

Through a single-drum control unit, each processor can have access to many large drums, each of which can store 1 million decimal digits, with complete single-digit addressibilty. Thus, the drum serves as an extension of the central core memory for program as well as information storage. Programs are primarily stored in the drums which have an average access time of 17 milliseconds, but transfer of information to and from the drum is controlled at clock rate after the data to be transferred is located. A few very frequently used programs are retained in the core memory, as well as a control information to locate the programs on the auxiliary drums.

Other peripheral subsystems not yet designed can be added, as required, after installation. This could include new random access memory devices, or a separate large auxiliary magnetic core memory for use in problems needing faster access to programs.

CONCLUSIONS

1. Large-scale integrated on-line data processing systems are economically and technically feasible.
2. The design requires a user and integrated system-oriented as opposed to a hardware-oriented approach.
3. These systems, which represent advance in system designs rather than any unique hardware development, are now in the process of cut-over for an airline and for several large regional savings banks.

REFERENCES

1. Design Techniques for Multiple Interconnected On-Line Data Processors, F. J. Gaffney, S. Levine. "Proceedings, Eastern Joint Computer Conference," Dec. 1957, Institute of Radio Engineers, New York, N. Y., pp. 173-77.
2. The Telecommunication Complex of An Airline Reservation System, H. K. M. Grosser. "International Symposium on Data Transmission," Delft, Netherlands, Sept. 19-21, 1960.
3. Communications Networks for Digital Information, J. M. Unk. *Transactions*, Professional Group on Communication Systems, Institute of Radio Engineers, vol. CS-8, no. 4, Dec. 1960, pp. 207-14.

BEATRICE A. HICKS

Monitoring densities of artificial atmospheres in hermetically sealed equipment

A recently developed method for monitoring leakage by sensing molecular density instead of pressure is a major step forward in the protection of high-density hermetically sealed equipment.

Performance requirements for miniaturized, hermetically sealed electronic and electromechanical equipment in air-borne applications place particular emphasis on the need for more efficient heat transfer and arc- or corona-suppression techniques. Artificial atmospheres such as dry air, nitrogen, sulfur hexafluoride, the fluorochemicals, or combination of these, each with its own characteristics, serve both as insulating media and cooling agents for more effective heat transfer and arc and corona suppression.

When these atmospheres are employed in air-borne applications, the need for a monitoring device to detect leakage of gases and/or vapors within the sealed assemblies or to detect when the atmosphere

A special article recommended by the AIEE Electronics Committee.

Beatrice A. Hicks is president and engineering director, Newark Controls Company, Bloomfield, N. J.

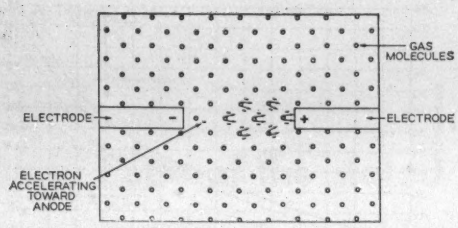


Fig. 1. Electrons accelerate in an electric field

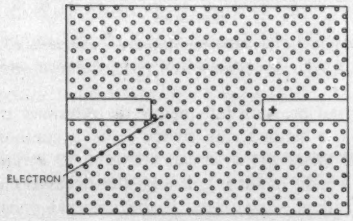


Fig. 2. High density of gas molecules prevents arc-over by shortening distance between collisions

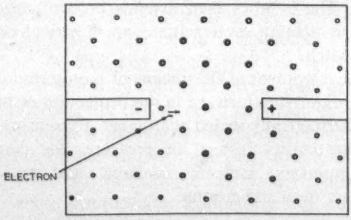


Fig. 3. Low density of gas molecules prevents arc-over by a scarcity of molecules

reaches a critical point for electrical arc-over or corona may make the difference in meeting high-altitude and reliability requirements. Heretofore, this problem was partially solved by the use of a pressure switch. However, the pressure switch has many limitations; for example, it can actuate only at one predetermined pressure throughout the temperature range.

Electrical arc-over is a function of molecular density and not pressure. Pressure of the hermetically sealed-in atmosphere varies over the temperature range without affecting the density of the molecules. On the basis of this principle, the density switch, which would monitor leakage by sensing the molecular density of the artificial atmosphere, was developed.

For gases and vapors alone, the density of the sealed-in atmosphere will remain constant over the entire temperature range. However, in gas/vapor systems that include liquid for the purpose of keeping the vapor saturated, the density of the sealed-in atmosphere increases with temperature rise as liquid evaporates.

When gas or gas/vapor is used as an insulator, a potential gradient exists in the gas or gas/vapor between two electrodes—a function of both their voltage and their distance apart. When the potential gradient exceeds a critical value, ionization occurs between electrodes. For example, a stray electron is accelerated by the high-voltage field between the electrodes toward the anode. If the speed attained by the electron is sufficient to give it enough energy to ionize a molecule of gas upon collision, then the electrons formed by the ionization of the molecule will, in turn, speed toward the anode. These electrons will hit more molecules with sufficient energy to ionize them. This effect multiplies until an avalanche of electrons speeds toward the anode, forming an arc (Fig. 1).

The energy level of the speeding electron is determined by the distance it has gone and its acceleration due to the electric or high-voltage field. Therefore, if the gas molecules are packed closer together, the density is increased and the electrons may not be able to develop enough energy to ionize the molecules they hit (Fig. 2). Only an increase in voltage would increase the acceleration of the molecules sufficiently to cause arc-over.

Conversely, if the molecules of the gas are so rare that electrons speeding toward the anode do not hit any of them or hit so few that ionization is not supported, then no arc-over will occur (Fig. 3). The effect described is commonly known as the Townsend effect.

For any specific gas or gas/vapor combination a graph may be plotted showing the arc-over voltage against density (Fig. 4). For every gas there is a density at which the conditions to produce arc-over are optimum. This is the minimum point on the curve.

Arc-over, therefore, is dependent on density. At different temperatures the density will develop different pressures which are independent of arc-over conditions. Presently, most available literature expresses this critical arc-over level in terms of pressure at a reference temperature. Pressure and temperature define the density of the gas according to the general gas law $PV = nRT$ or $n/v = P/RT$, where P is pressure, T is temperature, R is the universal gas constant, and n/v is the molal density. If arc-over data is taken in terms of pressure, it must always be converted for all the temperatures the equipment will ex-

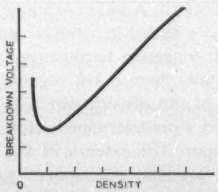


Fig. 4. Arc-over voltage varies with density of surrounding gas molecules

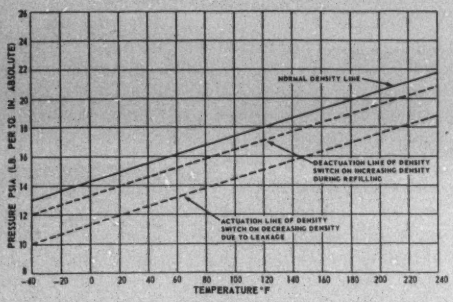

PRESSURE PSIA (LB. PER SQ. IN. ABSOLUTE)
TEMPERATURE °F
NORMAL DENSITY LINE
DEACTUATION LINE OF DENSITY SWITCH ON INCREASING DENSITY DURING REFILLING
ACTUATION LINE OF DENSITY SWITCH ON DECREASING DENSITY DUE TO LEAKAGE

Fig. 5. Linear pressure–temperature characteristic of a gas insulating medium

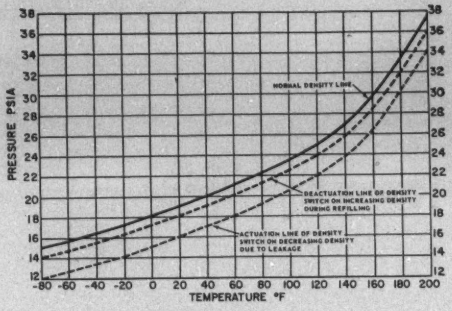

PRESSURE PSIA
TEMPERATURE °F
NORMAL DENSITY LINE
DEACTUATION LINE OF DENSITY SWITCH ON INCREASING DENSITY DURING REFILLING
ACTUATION LINE OF DENSITY SWITCH ON DECREASING DENSITY DUE TO LEAKAGE

Fig. 6. Nonlinear pressure–temperature characteristic of a gas/saturated-vapor insulating medium

perience. Consequently, proper monitoring of gases for arc-over requires the use of a density switch.

Unlike the pressure switch, the density switch is designed to have actuation pressures which vary in any positive relationship to temperature and is made to actuate or deactuate on the characteristic pressure-temperature curve of the sealed-in atmosphere. It is designed to actuate and deactuate a specified number of pounds per square inch above or below this curve in cases where the switch must anticipate critical conditions or when the switch must operate only after some definite drop in normal system pressure (Figs. 5 and 6).

The versatility of the density switch makes it suitable for a wide variety of applications. Wired to a remote indicating light, bell, buzzer, or control circuit, the density switch signals when the insulating gas or gas/vapor atmosphere approaches a critical danger point because of leakage, irrespective of changes in temperature or pressure. Aside from its use as a warning device, the density switch may be used to activate control circuits or systems; for example, it may open a valve or start a pump. Other applications include power tubes, power transformers, coaxial transmission lines, waveguides, X-ray equipment, and packaged electronic equipment.

One specific example is its use on the Boeing 707, where the density switch, housed in the rear antenna coupler, monitors the artificial atmosphere (nitrogen) used as an insulating agent in the sealed system by sensing the molecular density of the gas. If a leak develops and causes the artificial atmosphere to approach arc-over conditions, the switch actuates an alarm in the cockpit. Another example is in a missile which employs a sealed-in artificial atmosphere. The density switch triggers a telemetering signal back to earth if this atmosphere is lost because of leakage.

The heart of the density switch is a bellows, in which is sealed a predetermined reference density of gas or gas/vapor. The exterior of the bellows is exposed to the artificial atmosphere within the hermetically sealed equipment. The internal pressure of the bellows then follows the external pressure. When the external pressure falls below the reference pressure of the bellows, the switch gives a continuous signal of this drop or it can be wired to a remote control which, in turn, will take the necessary corrective action. Conversely, if the external pressure surrounding the bellows is greater than the pressure within the bellows, the switch can actuate. This actuation occurs when the two pressures are out of balance. The bellows then extends or contracts far enough to actuate or deactuate an electrical snap-action switch.

The development of this means of monitoring density is a major step forward in the protection of high-density hermetically sealed equipment. By sensing the molecular density instead of pressure, the density switch monitors, indicates leakage, and protects against arc-over and corona.

MINUTES EQUAL MONTHS with a new analog computer used by Minneapolis-Honeywell temperature control engineers to duplicate climate and building conditions anywhere in the world. The computer enables the engineer to obtain in 15 minutes technical data that would otherwise take years to assemble. Computer inputs simulate outdoor temperatures, wind direction and velocity, diurnal solar variations, latitude, and whether the sun is shining or covered by clouds. Information fed into the computer includes building size, type of construction, glass area, insulation, air-conditioning requirements, piping, and ductwork. Results are used to evaluate performance capabilities of new temperature controls.

C. G. VEINOTT

STANDARDIZATION: one of the stated objectives of the Institute

It has been proposed that AIEE turn over its traditional standards-making activities to the American Standards Association (ASA). The author, chairman of the AIEE Standards Committee, believes this would work to the detriment of the Institute, ASA, and electrical engineering itself. He sets forth personal arguments he hopes will generate a healthy discussion.

In the AIEE Constitution, the objectives of the Institute are stated as "the advancement of the theory and practice of Electrical Engineering and its allied Arts and Sciences, and the maintenance of high technical and ethical standards among its members."

In 1940, the AIEE Board of Directors approved a report by President F. M. Farmer, which contained the following statement of Institute policy:

Standardization in the electrical engineering field is an important element in the advancement of the art—one of the stated objectives of the Institute. Therefore, the Institute should take a prominent and, where appropriate, leading part in all standardization activities with which electrical engineering is concerned.

The title of this article is taken directly from the foregoing statement by ex-President Farmer.

Duties of technical committees, listed in Bylaw B-80.060h include ". . . within their respective scopes, initiate and prepare Standards . . .," clearly indicating the importance of formulating standards, an activity which promotes both of the stated objectives of the Institute.

WHO GENERATES INSTITUTE STANDARDS?

As early as 1890, six years after its founding, AIEE was instrumental in bringing about certain standardization for electrical units, and in 1898 the first AIEE Committee on Standardization was formed. In the early days, all of the standards were prepared by this Committee. Now, for the most part, Institute standards are prepared under the auspices of the technical committee within whose scope the subject properly falls. Two or more technical committees or subcommittees may co-operate by delegating the project to a joint working group. Standards which are very broad in scope, such as AIEE no. *1*, for example, are developed and revised by one of the standards co-ordinating committees (subcommittees of the Standards Committee). With this exception, the Standards Committee does not now prepare standards, but co-ordinates them within the Institute, and with other organizations that prepare standards. For purposes of co-ordination, all Institute standards are reviewed and approved by the Standards Committee.

INSTITUTE IDEAL FOR GENERATION OF STANDARDS

The basic technical structure of the Institute consists of some 55 technical committees, each one having a carefully prepared scope. In general, each committee has from 30 to 80 members. Usually, each committee member possesses a high degree of technical competence in the field, or has substantial interest in and knowledge of the subject within the scope of the technical committee. In essence, the membership of each technical committee represents a hard core of technical competence.

Many of the technical committees with a rather broad scope have set up several subcommittees, ranging in membership from about 5 to 50. Each of the subcommittees generally represents a higher and more specialized degree of technical competence in a more limited field than that of the main technical committee, but within its scope.

Some of the ways that these technical committees and subcommittees promote the objectives of the Institute are by writing papers, grading technical papers, developing committee reports, promoting technical sessions, and developing standards. In most cases, even a subcommittee is too large to write a standard effectively; also, there may be more than one subcommittee involved, so that the actual prepa-

A special article recommended for publication by the AIEE Standards Committee.

C. G. Veinott, Fellow, AIEE, is chairman of the AIEE Standards Committee. He is with the Reliance Electric and Engineering Company, Cleveland, Ohio.

ration of a standard is usually designated to a working group. When the working group develops a proposal, it is submitted to the entire technical committee for review and approval. Sometimes a great deal of technical data must be gathered, and considerable discussion held, in order to arrive at a reasonable consensus of the interests represented. In such a case, the working group, and/or its sponsoring subcommittee or technical committee, promotes papers and holds discussions, symposia, or technical conferences, or does whatever is needed to bring out the varying and differing views. When a number of technical or conference papers on a standards subject are presented to the Institute, these sessions are open to the public, and the individual AIEE member, after hearing various points of view, may express his own convictions. Papers considered to have permanent reference value are published in the *Transactions;* thus those who miss the sessions often may obtain the background from which a standard has been developed. These opportunities for extensive verbal discussion by the general membership, and for documentation, do not exist in many other organizations, including trade organizations, and the ASA (America Standards Association) itself.

AIEE is composed of individual members, each with considerable freedom of thought and action. Moreover, there is usually within AIEE a great breadth of interests represented. The environment is favorable for free discussion, with good opportunities for resolving conflicts of interest. There is less likelihood of reaching an impasse than there is in a committee of individuals, many of whom are bound by outside instructions.

Within the framework of AIEE, therefore, are presented important advantages in the development of a standard: (1) an adequate reservoir of qualified personnel from which to draw the writing group; (2) opportunities for public discussion of standards proposals by a large, technically competent section of the membership; (3) opportunities for "the still, small voice" of the individual to be heard; and (4) opportunities for the permanent recording and documentation of supporting data where they will be available as a permanent record. By the time an Institute standard has been developed by its working group, approved by the appropriate technical committee and by the Standards Committee, the proposed standard has already come to the attention of a considerable number of people with highly specialized interests in and knowledge of the subject on which it is written. As a result, the standard is usually well on its way toward acceptance by the time it has been issued. It is usually a good standard!

STANDARDS MAKING DEVELOPS PARTICIPATING ENGINEERS

The give-and-take discussion and the work necessary to prepare a proposed standard are often highly stimulating to the individual engineer who participates in this project. The activity puts him in touch with others in the same field, helps him to refine and clarify his own ideas, and enlarges his sphere of knowledge and general technical competence. It helps him to test out his ideas. He learns to respect the opinions of others, to forge compromises, and to hold steadfast on important issues but to yield quickly on less important ones. This activity certainly helps him in the maintenance of high technical and ethical standards.

IN WHAT AREA SHOULD AIEE STANDARDS BE GENERATED?

A certain amount of confusion exists concerning the areas in which there should be Institute activity in the development of standards. These areas are not clearly and precisely defined, and some consider this the better way. At the risk of oversimplification, the writer's personal views are that the Institute should be concerned principally with those standards where the contents are mainly technical or scientific in nature—as distinguished from commercial or economic standards—within the scopes of the technical committees. Where the principal concern of the standard deals with economic and commercial matters, the standards making should preferably be left to trade associations, such as NEMA (National Electrical Manufacturers Association). As an illustrative example, AIEE no. *85* concerns itself with a proposed test procedure for measuring the noise of rotating electric machinery, a technical and scientific problem.[1] The standard does not concern itself with stating what levels may be expected of normal commercial apparatus. How noisy a motor should be is a more appropriate subject for a trade organization such as NEMA, whose experts are currently developing an answer to this question. The term "product standard" is sometimes used in a very broad sense. Of course, there are many other standards that come in classifications outside of the two just mentioned, such as safety standards. Some further definition of the areas of the Institute's interest would be helpful.

JOINT DEVELOPMENT OF STANDARDS

In those areas where the Institute has the technical competence and adequate representation to develop a standard entirely by itself, it is usually desirable for it to do so, particularly where AIEE has a primary interest. However, where another society has technical competence and interests which so overlap that the areas of interest cannot be separately defined, and where it is able and willing to co-operate, usually a better standard can be produced jointly. Because of the great overlapping of interests of the AIEE and IRE (Institute of Radio Engineers), an AIEE-IRE Joint Standards Committee has recently been set up.

Whether a standard should be prepared jointly with another organization should depend on whether or not something can be gained by joint action. Often, joint action is more cumbersome and slower, and unless there are definite advantages, AIEE might better do the job alone.

Sometimes more than one other society is interested; for example, AIEE, IRE, and ACM (Association for Computing Machinery), are jointly preparing a computer glossary. Such joint action by the three societies is highly logical, for these three societies have co-operated for several years in promotion of activities in the computing field, notably the Eastern and Western Joint Computer Conferences. A glossary developed by a joint working group of three societies should be better than a glossary produced by any one of them working singly.

ASA—A CO-ORDINATOR OR A GENERATOR OF STANDARDS?

In some circles, a move is under way to reduce the influence and responsibilities of the technical societies, including AIEE, in the field of standards making. Basically this would mean confining the societies' activities to naming their representatives on ASA Sectional Committees and abandoning their own standards-making operations.

Full responsibility for supervising and co-ordinating activities regarding standardization would be assumed by an appropriate ASA sectional committee. AIEE, for example, could not initiate any standardization activities unless asked to do so by the sectional committee. Standards would be generated by writing groups set up by and reporting to the sectional committee.

The two principal arguments advanced in favor of such a procedure seem to be that it would (1) reduce the cost of making a standard by reducing the number of people and reducing duplication; and (2) speed the process of generating the standards. Other corollary arguments are advanced.

In the writer's opinion, these proposals overlook some even more important points which should be considered. Moreover, the arguments are not really as strong as they might appear. Let us examine some of the aspects and implications of such a policy.

STANDARDS MAKING NOT ORIGINAL PURPOSE OF ASA

First, the proposal definitely violates the original aims and purposes for which ASA was formed. This is amply evidenced by the ASA Constitution,[2] which states, as the first two objectives:

> Section C 2.1—To provide systematic means by which organizations concerned with standardization work may cooperate in establishing American Standards, to the end that duplication of work and the promulgation of conflicting standards may be avoided.
>
> Section C 2.2—To stimulate the work of existing committees and other organizations competent to formulate standards . . ., but [the ASA itself] not to formulate standards.

Also, in the same document: ". . . ASA takes up new projects only upon request . . ." and "does not make specific negative decisions, for example, either against initiating a project, or for stopping a project already started."[2]

In another ASA publication:[3]

> In 1918, five leading American engineering societies decided to form a national organization that would coordinate the development of national standards.

Farther along in the same document is the statement that "The ASA does not write standards."

Now there is no reason why the ASA, like any other organization, should not adapt itself to changed conditions or to new needs *provided new conditions warrant a change*. But ASA was originally set up to *stimulate other bodies in the making of standards and to co-ordinate their efforts*. There were then good reasons for setting it up this way and these are valid today. Until there are good and sufficient reasons for a change—and I do not think there are—no such radical change of policy should be made. The arguments against the change outweigh those for it. In addition, ASA could lose some of its judicial impartiality if it should become both author and critic of the same standards. AIEE would lose in surrendering so important an activity and the quality of American Standards would likely suffer.

REDUCTION IN COSTS

To the extent that fewer people would participate, costs to the untrained eye would most certainly be reduced. However, if economy is the main consideration, why not commission two or three individuals to write the standards? The fewer who write, the fewer there are to reconcile their views and the more economical it is to write the standards!

By the same token, we might say: Reduce the costs by not sending engineers to attend any of the technical conferences and meetings of the Institute; preparation of papers and sending engineers to attend the conventions cost money.

In an age when cost cutting has become a vital need in the electrical industry, such an argument can close our eyes to more important factors: the development of the individual, wider publicity given to standards, possibilities for public discussion, opportunities for documenting substantiating data, and opportunities to introduce points of view that may have been overlooked.

SPEEDIER DEVELOPMENT?

The argument is advanced that fewer people would develop standards faster because they would be subject only to ASA procedures, and not to those of AIEE and ASA. This argument is not so sound as it appears, for there have been numerous instances where the ASA procedure took longer than AIEE

under comparable circumstances. A recent example is afforded by AIEE no. *85*, started some 2 years after a more general ASA standard was being prepared in a sectional committee. Both AIEE and NEMA needed the standard. The AIEE version has been available for some time, and is currently being used by NEMA, but the ASA standard upon which it was to have been based has not yet been issued.

The writer does not imply that this is the usual case, but merely wishes to point out that AIEE procedure is not necessarily slower than that of ASA, and there are many who feel that the converse is true. However, some streamlining of procedure is needed in both of the organizations. A well-prepared AIEE standard can serve a useful purpose by itself; moreover, it should require but little change by ASA.

TECHNICAL COMMITTEES AND SECTIONAL COMMITTEES

In some cases the generation of a standard by an ASA sectional committee may well represent the most practical procedure, as in the case where many societies have their own respective major stakes in the standard, and where no one society stands out as pre-eminent in the particular field. Here a joint committee representing a large number of societies would be rather unwieldly in administration, and the sectional committee method could well represent the best solution. However, where one society is pre-eminent in technical competence and has a clear-cut principal concern in a particular area of standardization, preparation of the standard by the cognizant technical committee of the technical society may well be better than formulation by the sectional committee.

There is probably no such thing as an absolutely typical case, because circumstances vary widely. However, as an illustration of the case wherein a society is pre-eminently competent to write a particular standard, let us consider a specific example in the field in which the writer is most familiar. The example is not necessarily more deserving than others, but it is chosen because of intimate first-hand knowledge. Let us consider ASA Sectional Committee *C50* (rotating electric machinery), and examine the suggestion of those who say that the AIEE should limit its participation in this field to the appointment of its representatives. On this important Sectional Committee are six AIEE representatives and two alternates. The principle AIEE technical committee concerned with *C50* is the AIEE Rotating Machinery Committee (RMC), which has a total membership of 82 members. Is it reasonable to expect the six AIEE representatives on ASA *C50* to have all the information, creative ability, and talent of the 82 rotating machinery specialists? In addition to these 82 on the RMC proper, its various subcommittees have a large number of additional members with even more highly specialized interests. For example, the Induction Machinery Subcommittee (of the RMC) has 39 members, 24 of whom are in addition to the 82 members of the RMC itself. A similar situation exists for many of the other subcommittees. But this is not all of the story. Five other AIEE technical committees have expressed interest in the activities of ASA *C50*. Total membership of these other five committees amounts to 221 on the main committees, making a total of 303 members interested in this work. Are a mere 6 expected to represent these 303 members, who are themselves backed up by many additional members?

The difference of sheer numbers in talent, experience, and competence available in the AIEE technical committees, as compared with the small group of AIEE representatives on sectional committees, is overwhelmingly in favor of the technical committee.

In some sectional committees, the problem of obtaining suitable recognition of AIEE interest and talents is even more severe and can be limited by a sponsor. This problem was particularly acute in the case of one recently organized ASA sectional committee. At first, the sponsor was unwilling to accept even a single AIEE representative, as he wanted all engineering societies to be represented by a single representative, named by the Engineers Joint Council (EJC). The sponsor, however, finally yielded and allowed one AIEE representative. There were two AIEE technical committees, from different divisions of AIEE with widely different interests, both of which felt that they had a definite interest in the work of this sectional committee and wanted representation on it. In the meantime, a third AIEE technical committee, which perhaps had even more at stake than the other two, also wanted representation, but the sponsor denied at least two requests from AIEE for two representatives, and AIEE was eventually forced to settle for the single representative. While this particular case is probably an exception to the general rule, it does present a somewhat alarming picture of what can happen.

EXCESSIVE INTEGRATION IN ASA STANDARDS?

Let us now return to a discussion of ASA *C50*. It is the writer's understanding, and the material in the standard seems to bear this out, that most of the material for *C50* is taken from older AIEE and NEMA standards, and integrated into a single standard. Consequently, since AIEE and NEMA had approximately equal interests, it was considered better not to name either or both as sponsor, but to give the sponsorship to the Electrical Standards Board, despite the fact that ASA does not write standards. Perhaps it would have been wiser to have kept the two materials separate, letting AIEE and NEMA maintain their respective portions. The *C50* Committee could have co-ordinated the efforts of the two.

The AIEE Test Code AIEE no. *500* was taken over as ASA *C50.20*. In the first edition of *C50.20*,

AIEE no. *500* was retained intact and published as a separate pamphlet. If past practices are any indication, it could well be that at some time in the future, this would be integrated with ASA *C50.2*, and the AIEE number and identity dropped and lost, as well as AIEE responsibility for maintaining it. This could easily happen since *50.2* and *50.20* are both sponsored by the Electrical Standards Board. In the writer's opinion, the present arrangement of having them in two pamphlets is in general more useful; also, it will be easier to keep them up to date. Recently, for example, AIEE has put through a revision of AIEE no. *500*, which means changing only the pamphlet *C50.20*, with no change in *50.2* being required.

It is suggested here that the sponsorship of ASA *C50.20* be returned to AIEE. It it also suggested that consideration be given to reorganizing the material into sections which could be maintained and kept up to date by appropriate standards-making bodies, equipped to do the task, such as AIEE, NEMA, and EEI, for example. Co-ordination between these sections would still be afforded by the ASA *C50* committee, but its function would be co-ordination rather than creation.

To repeat, specific examples have been used for conveying the point more easily. There may well be other standards in a similar condition.

SOME SUGGESTIONS ON INSTITUTE POLICIES AND STANDARDIZATION

In the writer's opinion, the words of ex-President Farmer are just as applicable today as they were when written in 1940: "The Institute should take a prominent, and where appropriate, leading part in all standardization activities with which electrical engineering is concerned." Some suggestions are made for implementing this general policy:

(1) Define its particular area in the field of standardization; and make sure that this definition is properly promulgated to all technical committees and to all AIEE representatives on ASA sectional committees, and other standardizing bodies.

(2) Examine its own procedures with a view to streamlining them without sacrifice of quality of output.

(3) Stimulate and encourage the Technical Committees to initiate and prepare standards within their scopes.

(4) Continue to strive for closer working relationships between its representatives on Sectional Committees and the appropriate Technical Committees.

(5) Make a study to determine what present ASA standards, or parts thereof fall within an area of prime interest to AIEE; and seek sponsorship of those that do.

(6) Submit to the ASA appropriate AIEE standards for approval as American Standards.

(7) Study the most appropriate method for obtaining ASA approval. In some cases this may be by the Sectional Committee method. In other cases AIEE might well emulate the example of the Underwriters' Laboratories, who have standards approved by the existing standards method without loss of identity as UL standards, and without loss of responsibility for their maintenance.

(8) Maintain AIEE identity and recognition in ASA standards, prepared and approved by AIEE. This recommendation is made so succeeding generations of technical committees will realize that AIEE has the responsibility for maintaining and keeping these standards up to date. An ad hoc committee of the Standards Committee is investigating this subject.

CONCLUSION

For AIEE to abandon its historic role in standards work in favor of turning it over to representatives on sectional committees would be for it to abandon "an important element in the advancement of the art—one of the stated objectives of the Institute." It would wipe out a major *raison d'être* of a number of its important technical committees. Past President Harold Foote urges that we try to put as many of our AIEE members to work as possible in order to have a strong organization, and to make an important contribution to our profession. Abandonment of standards making is certainly inimical to that objective.

REFERENCES

1. Proposed Test Procedure for Noise Measurements on Rotating Electric Machinery, AIEE *Special Report no. 85*, Nov. 1960.
2. The ASA System, the Constitution, Bylaws, and Procedure of the American Standards Association, Inc. *Pamphlet no. PM125a*, American Standards Association, New York, N.Y.
3. How American Standards are Made, *Pamphlet no. PM156*, American Standards Association.

COLORFUL SOUND

By the early 1970's the wall paint in rooms of private homes will contain special sound-conducting chemicals, eliminating the use of hook-up wires, according to Richard Ekstract, chairman of the "New York Hi-Fi Show," held last month at the Trade Show Building in Manhattan. A record player, contained within a 3- by 3-inch box powered by molecular electronic amplifiers, will be "tuned" to the wall frequency of the room for operation. Records will be tiny wafer-like cards, containing an entire evening of music, that slip into the little black box.

But that's only the beginning. According to Ekstract, "the walls of the listening room will change color according to the music being played. The sound frequencies will alter the chemical content of the wall paint so that certain sounds will produce blues, other sounds, reds, yellows and the like."

E. K. HOWELL

Photoelectric controls for street lights

The use of photoelectric devices to control street lights has grown rapidly in recent years. Many new types of devices have been developed but, in several areas, there is uncertainty as to how they can best be used. An analysis of the character of natural light at dusk and dawn is presented, and criteria for control of street lights is defined so that the user may evaluate the control devices to best advantage.

Ideally, street lights should be operated only when they are needed. Photoelectric controllers do just this by measuring the amount of natural light available and turning on the street lights whenever the natural illumination is below a given preset level.

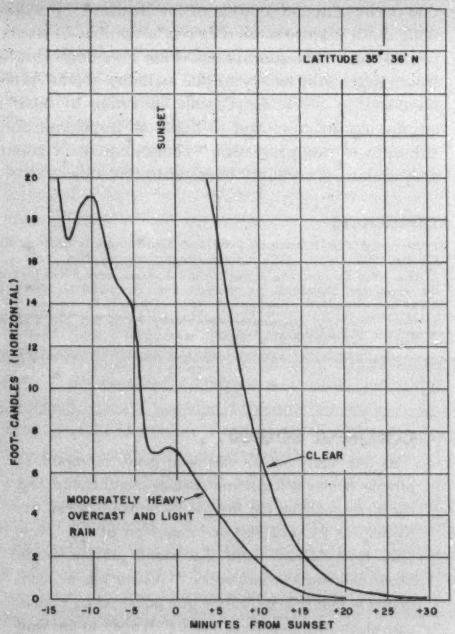


Fig. 1. Typical light decay at dusk for clear and overcast sky

Only by the use of photoelectric control can it be assured with economy that street lights will be energized during the highly dangerous twilight interval when natural daylight decreases faster than the light-adapted eye can become dark-adapted.

A special article recommended for publication by the AIEE Production and Application of Light Committee.

E. K. Howell is with the Outdoor Lighting Department, General Electric Company, Hendersonville, N. C.

The determination of the point-of-need for having street lights turn ON has been a problem since the beginning of street lighting. Before the days of accurate measurement of illumination and the scientific determination of the illumination required for the performance of various tasks, most people associated darkness with time and set up various definitions of twilight and need for street lights on a time basis. Even now, there are many street lighting contracts calling for a specific number of hours of operation per year, or establishing a time schedule for TURN ON and TURN OFF. Such specifications can be met only with timer switches and they result either in wasted power to assure that the lights are on when needed, or in hazardous driving conditions should weather, season, or power failure upset the expected conditions. An examination of the character of natural illumination at dusk and dawn shows the inadequacy of time specifications.

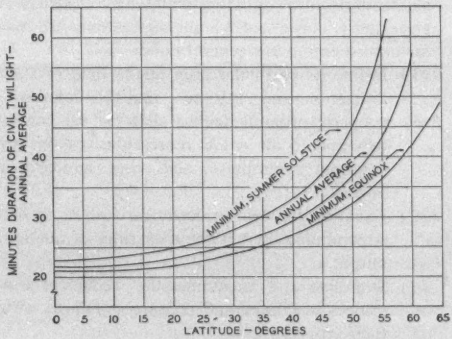


Fig. 2 Duration of civil twilight vs. latitude

Many factors determine the time at which a given level of natural light occurs, and the total annual hours when natural illumination is below that given level. The major factor for most of the United States is weather and atmospheric conditions. Fig. 1 shows typical light vs. time curves for clear and over-

cast conditions at latitude 35 degrees 36 minutes north. The time difference between equal foot-candles varies from 6 to 18 minutes on these curves and is known to vary as much as 30 minutes with extremely heavy overcasts at this latitude. Differences of 1 to 2 minutes have also been observed on apparently equal clear, cloudless days because of the effects of dust particles, water vapor, ozone, and air density which affect the angle of refraction of sunlight. Note that light levels shown in Fig. 1, and throughout this article, are expressed in terms of the illumination in foot-candles on a horizontal surface such as a street. The illumination on a vertical surface is nominally one half that on a horizontal surface but is dependent on orientation of the vertical surface; hence it should not be used when street lighting is considered.

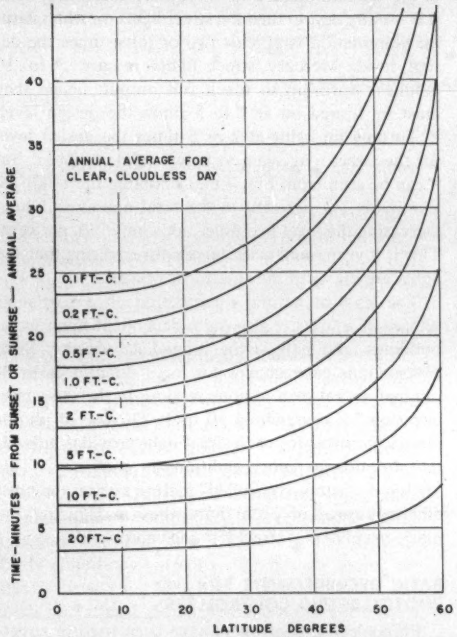


Fig. 3. Effect of latitude on time from sunset at which various light levels occur. (Sky is clear)

Latitude and season are also significant factors to be considered. Under clear conditions, the primary factor which controls the light level is the vertical angle of the sun from the horizon. Precession of the earth causes the vertical angular velocity of the sun (considering the earth stationary) to vary with latitude and season, resulting in varying lengths of twilight. Fig. 2 shows the effect of latitude on the annual average duration of civil twilight and the minimum and maximum seasonal fluctuations. Not only does the average duration of twilight increase with latitude, but the extent of seasonal variations also increases with latitude. At latitude 65 degrees, the average and maximum are both indeterminate since twilight persists all night during the summer months.

Precession and refraction also cause the total annual hours between sunset and sunrise to be dependent on latitude. Compounding this effect is the lengthening of twilight with latitude, with the resulting changes in time after sunset at which various light levels occur, as shown in Fig. 3. The data represented in Fig. 3 is the annual average for clear, cloudless days. Fig. 4 shows the total annual hours during which natural illumination is below the indicated light levels, based on 365 clear, cloudless days.

It is clearly evident, therefore, that a perfect light-sensitive control device, operating under ideal weather conditions at a given level of illumination, cannot produce the same number of operating hours per year at different latitudes. From the southern tip of Florida to the northern tip of Minnesota is an inherent spread of 140 hours per year at the 0.5 foot-candle level.

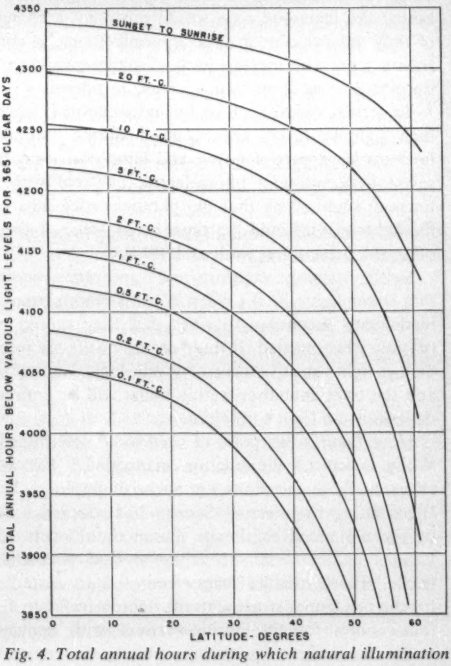


Fig. 4. Total annual hours during which natural illumination is below various levels as a function of latitude

Weather conditions, as shown in Fig. 1, are even more significant than latitude in determining operating hours. The weather at each particular locality is sufficiently random as to be nearly unique to that locality. This is especially true when weather is considered only during the brief intervals at evening and morning when switching occurs. There are no records available of dusk and dawn weather conditions

for several years at various locations to permit calculation of "average" conditions at those locations. Even if there were, one could not be safe in using the data for future years, nor for other locations, because of the low factor of certainty involved. With the data in Fig. 4, however, one can determine the minimum operating hours for a given light-level, then estimate the effect of weather conditions in minutes at dusk and dawn, convert the minutes to annual hours above minimum, add this to the minimum hours, and get a figure which is probably accurate to ±5 per cent or better.

For those whose concern for total annual operating hours is based on concern for annual kilowatt-hours, it is well to consider the fact that variations in line voltages and lamp characteristics produce power variations which generally overshadow such small variations in time. For example, if fog or clouds cause TURN ON to be 15 minutes early and TURN OFF to be 15 minutes late every day for a year, the increase in total operating time would be 182.5 hours. If perfectly clear conditions produce 4,150 total hours, the increased time would represent a change of only 4.4 per cent in total kilowatt-hours; in contrast a 5 per cent increase in line voltage would produce at least an 8 per cent increase in power.

In certain cases, such as business districts, where high lighting levels are required during business hours, a large part of power and lamp costs may be saved by combining photoelectric controls with a timer in such a way that the photoelectrics turn on the lights at dusk and the timer turns some of them off at the preset time, such as 1:00 a.m.

Safety, visibility, comfort, and appearance require that street lights be ON when natural illumination is inadequate. Economy specifies that they should be ON only when needed. If these requirements are to be met, a light-sensitive control is the logical solution, and the total annual operating hours will be entirely dependent on local conditions.

How, then, is this point of need to be determined? When is natural illumination inadequate? The answers to these questions are surprisingly easy. The Illuminating Engineering Society has adopted a set of recommended minimum illumination levels for various combinations of vehicular and pedestrian traffic. These minima range from 0.2 foot-candles for the residential street with the lightest traffic to 1.2 foot-candles for the business street with heaviest traffic. Since these figures are minima, the demands on street lighting also increase as night traffic increases; many installations have higher values.

The trend toward high illumination is in agreement with the findings of several organizations which are conducting basic research in night-time driving vision requirements. According to recent Highway Research Board reports, significant improvements in visibility are obtained at lighting levels many times higher than the present standard minima.

Each street-lighting system is designed to produce a certain average illumination on the street, in accordance with the needs of that street. Therefore, if natural illumination is less than that for which the street lighting was designed, it is inadequate and the street lights should be turned on. However, to avoid a large jump in light level and to account for the lag in eye accommodation to the rapidly decreasing light, it is usually best to turn the street lights on when natural illumination is at least two or three times the design level. Mercury street lights require 5 to 10 minutes' warm-up to reach full output; hence they must be turned on at 2 to 5 times the design level.

Turning on lights at 2 or 5 times the design level for the street may seem to be wasteful of power, but it can be seen from Fig. 4 that doubling the TURN-ON level adds 1.0 per cent to the total operating hours; increasing the level five times adds only 2¼ per cent. This is a very small price to pay for ensuring that the lights are on when they are most needed.

The level of natural illumination on a particular section of a street is also quite dependent upon trees, buildings, and hills in the immediate vicinity. Such obstructions can account for large differences in illumination between various sections in the same city, occasionally as much as 10 to 1. The use of photoelectric controls for each street light provides individual attention to light conditions in each area. This "tailored, custom-controlled" feature assures the most efficient usage of each light, thus maximizing the many benefits that street lighting can provide.

BASIC REQUIREMENTS FOR PHOTOELECTRIC CONTROLLERS

Photoelectric controllers have been used in street-lighting systems for many years, and the use is now increasing at a very rapid rate as more people become familiar with their unique advantages. With this upsurge in use comes also a bit of confusion resulting from misunderstandings as to what photoelectric controls can and should do, and how they should be used to best advantage.

For a controller to determine accurately the illumination on the street, it should have the light-sensitive element mounted in the street surface, but there are obviously many practical limitations which prevent this. Mounting the photocell within the controller atop the pole or on the luminaire has been found reasonably accurate. Most photocells cannot tolerate prolonged exposure to direct sunlight; hence they are mounted with a view of the north sky only. This results in some variations in operating point caused by clouds, but such variations are normally less than 2 to 1. In general, any variations caused by trees, buildings, or hills are also evident in illumination on the street and should be accounted for by the photoelectric controller. Fortunately, nearly all such variations are in the safe direction, i.e., the street lights are turned on at a higher level of natural illumination, rather

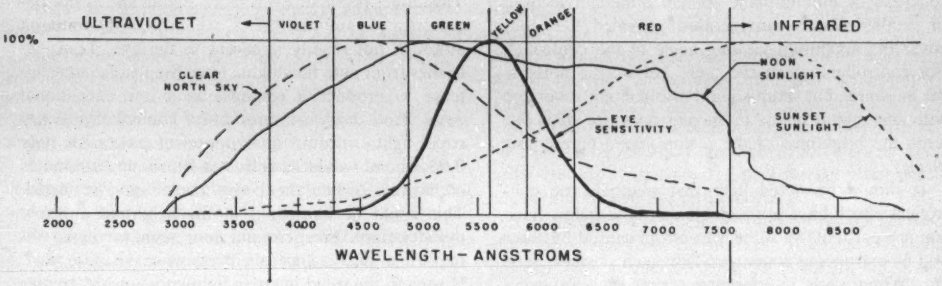


Fig. 5. Approximate spectral composition of natural illumination

than at a lower level, which could be a hazardous condition.

Since street lighting is based primarily on visibility, radiant energy outside the visible portion of the spectrum is of no interest. Therefore, the ideal photocell should have a spectral response identical to that of the eye. Spectral sensitivity of the eye is represented in Fig. 5, along with the approximate spectral content of noon sunlight, sunset, sunlight, and clear north sky light. After sunset, during the twilight period, the peak in the red gradually shifts over to the blue. The exact spectral content during twilight is quite variable, depending on the nature, amount, and distribution of ozone, water vapor, dust and smoke particles, clouds, and water droplets in both the lower and upper parts of the atmosphere. Photocells which respond to radiation outside the visible spectrum will not indicate visibility conditions correctly, but if their major response is between 4,000 and 7,500 angstroms the error in operating light level will usually not exceed 2 to 1.

For precise measurement of illumination, photocells are provided with filters which make the spectral response of the photocell very nearly the same as that of the eye. In addition to being color-corrected, a photocell must also be made to have a response proportional to the cosine of the angle of incidence of light on the cell surface. Since street lighting is concerned with illumination on the street surface, measurements of such illumination are made with a conventional color-corrected and cosine-corrected photocell mounted in a horizontal plane. Photocells with such corrections are quite expensive and are not warranted in the photoelectric controllers themselves, especially where TURN ON occurs at 2 or 3 times the design level for the street and a variation of 2 to 1 in the operating point produces no serious consequence.

Although such wide variations may be tolerated in operation without serious effects, the standards of measurement must be accurate and precise, in keeping with sound engineering practice.

Basic measurements of operating light levels should be based on the performance of the photoelectric controllers mounted in full exposure to the sky, to within 5 degrees of true horizon, and shielded from any artificial light. Operating light-levels are defined in foot-candles of natural illumination as determined by measurements using a conventional color-corrected and cosine-corrected photocell mounted in a horizontal plane, with full exposure to the sky to within 5 degrees of true horizon, and located within 1 foot vertically and 15 feet laterally of the controller under test. This establishes a direct measurement of actual operation in natural light, measured in exactly the same manner and the same system of units as is used to determine illumination on a street.

The nominal, or rated, operating light level may be determined by taking the average (or minimum, perhaps) of measurements recorded on at least 3 clear, cloudless days and corrected to an ambient temperature of 25 C if necessary. In this manner, the minimum operating level is obtained, usually to a precision of ±5 per cent. This minimum level is of major significance because TURN ON must occur before natural illumination reaches the street-lighting design level. As mentioned earlier, clouds, trees, buildings, and hills can raise the TURN ON level, which is an acceptable direction of change. The minimum level is therefore the best nominal, or rated, value for general use.

Once such daylight measurements have been made for a particular type of photocell, a correlation can be established for measurement in artificial light. A separate correlation is required for each type of photocell because of differences in spectral response of the photocells, differences in spectral content between artificial light and daylight, and differences in per cent of sky each photocell can see. The manufacturer of the photoelectric controller can usually supply such correlation as well as specific recommendations on the equipment to use for artificial-light measurements.

Photoelectric controllers which have a fixed solid angle of view less than one hemisphere can be measured by using a point source of light and varying the illumination by changing distance from source to photocell. Illumination is then easily determined by the inverse-square law.

Those controllers which have a variable solid angle of view or which can see more than one hemisphere must be measured preferably with the use of a hemi-

spherical or infinite-plane source. Spherical sections or smaller planes can be used provided that they cover the maximum viewing angle of the controller. For controllers which can "see" below true horizon, the measurement setup should also contain a horizon with the region below it, having no more than one tenth the brightness of the region above (preferably black).

It should be noted here that photoelectric controllers which have appreciable response below horizon are particularly subject to errors caused by snow and by extraneous sources of light such as signs, cars, etc. When such interference occurs, it can occasionally be relieved by turning the controller away from the offending light. Because direct sunlight can seriously shorten the life of most photocells, this rotation should not exceed 45 degrees from north for controllers which are normally north-oriented.

There has been much debate on the value of having a time delay in the photoelectric controller. To avoid response to transient flashes of light, a photoelectric controller should have a time delay. Although flashes of lighting are very short in duration, their intensity is often so great as momentarily to saturate and paralyze photocells and their control circuits. This effect becomes even more significant in the occurrence of multiple flashes, which is fairly common although not readily apparent to the eye, Transient flashes from auto headlights have been sufficiently intense to produce a response in a few exceptional cases. Time delay is important for control of mercury street lights since an interruption of power for only 0.02 second would be followed by about 10 minutes of darkness while the lamps cooled and restarted. This could be hazardous at the height of a heavy thunderstorm. Filament and fluorescent lamps do not require a delay since their response is quite fast. However, the trend in street lighting is toward greater use of mercury lamps.

The two major objections to having a time delay are (1) cost of obtaining a delay which is independent of light level, and (2) maintenance men must wait for the unit to operate when installing new units or new lamps. The latter applies to delays greater than about 3 seconds. Delays of less than one second are not generally effective in preventing operation by lightning; delays longer than 60 seconds are not desirable because of increased differential between TURN ON and TURN OFF light levels, and because of greater difficulty in getting good measurement and adjustment of operation with artificial light. In measuring controllers under artificial light, the time delay can produce false readings unless care is taken to change light level slowly, preferably at the normal daylight rate, such as shown in Fig. 1 for clear conditions.

The undulations in light level which occur under a moderate overcast with strong winds (Fig. 1) can cause erratic operation if the differential in light levels of TURN ON and TURN OFF is too low. It has been found that a differential of 1.4 to 1.8 (TURN OFF level 40 per cent to 80 per cent higher than the TURN ON level) will prevent cycling in virtually all cases and should be used even though it adds 1 or 2 extra minutes of operation each morning. Greater differentials are usually of no advantage.

The economic significance of differential, sensitivity, and life is given in Table 1, based on the following conditions:

1. Rate of change of natural illumination is 2 to 1 every 4 minutes (approximate national annual average).
2. Average load per unit: ½ kw.
3. Assumed rate for power: $0.017 per kw-hr.
4. Estimated average cost for replacing defective control: $5.00 plus price of new unit.

In the example shown, it is obvious that the lamp load and the life of the controller are the major economic factors, with the effects of sensitivity and differential being comparatively small. As noted earlier, a very small change in load power can completely overshadow the economic effects of differential and sensitivity.

Table 1 . ECONOMIC FACTORS

1. Sensitivity: (TURN-ON light level, equal to TURN-OFF level)

Relative Turn-On Light Level	Extra Dollars per Year per Unit
10	+ 1.378
5	+ 0.964
2	+ 0.416
(Base) 1	0
0.5	− 0.416
0.2	− 0.964
0.1	− 1.378

2. Differential: (Ratio of TURN-OFF/TURN-ON light levels)

Ratio	Extra Dollars per Year per Unit
5	+ 0.482
2	+ 0.208
1.5	+ 0.122
(Base) 1	0
0.75	− 0.122
0.5	− 0.208
0.2	− 0.482

3. Life: (X is unit price)

Years	Dollars per Year per Unit (X = 20)	
1/2	10.00 + 2X	50.00
1	5.00 + X	25.00
2	2.50 + 0.5X	12.50
5	1.00 + 0.2X	5.00
10	0.50 + 0.1X	2.50
20	0.25 + 0.05X	1.25

4. Total Annual Operating Cost:

	Example	
Load	(4,150 hours, 1/2 kw)	35.30
+ Sensitivity	(0.5)	− .42
+ Differential	(1.5)	+ .12
+ Life	(5 years, X = 20)	+ 5.00
Total		40.00

As far as the photoelectric controller alone is concerned, a long, maintenance-free life is the most desirable characteristic of all. Some of the factors which can affect controller life are:

1. *Environmental conditions:* sunlight, heat, humidity, rain, dust, corrosive vapors, etc.
2. *Electrical conditions:* Lightning surges, excessively high or low line voltages, excessive load current and short circuits, etc.
3. *Mechanical damage:* shipping and handling, excessive vibration or impact, projectiles, etc.

The controller must be designed to withstand all these hazards, within reasonable limits, as well as to provide correct operation consistently.

Most present controllers now use, as the light-sensing element, some form of photoconductor. The polycrystalline cadmium-sulfide (CdS) photoconductor has been found ideally suited to street-lighting controls since it can control a relay directly, without amplification, and has a spectral response essentially centered in the visible region. Properly constructed and hermetically sealed photocells of CdS have excellent stability when used within their voltage and power ratings. These photocells have a property of becoming light- and dark-adapted, which requires preconditioning prior to laboratory measurements or adjustment of unit operating point, but results in a smaller differential in actual operation.

These new photoconductors have greatly stimulated photoelectric control of street lights by making possible smaller sized units at lower cost and with greater life and reliability than ever before. Photoelectric controls are now regarded as essential from both the economical and technological points of view, and are therefore making a major contribution toward bringing the safety, security, and comfort of street lighting to more people, from the isolated farmhouse dwellers to those in the largest metropolises.

APPENDIX: DEFINITIONS

1. Sunset (or sunrise): Time at which the upper limb (rim) of the sun appears on the horizon. Because of atmospheric refraction, the true position of the center of the sun is 50 minutes below horizon at this time, on the average. (Refraction 34 minutes, solar radius 16 minutes.)

2. Civil twilight: Interval between sunset, or sunrise, and the time when the true position of the center of the sun is 6 degrees below the horizon, at which time stars and planets of the first magnitude are just visible and darkness forces the suspension of normal outdoor activities.

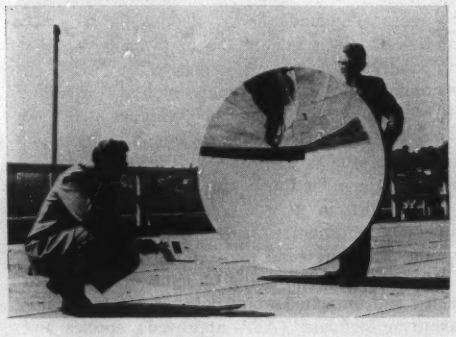
3. Refraction: Angular bending of the sun's rays by the earth's atmosphere. Equal to the angular difference between apparent position and true position of the sun. The angle of refraction increases rapidly as the sun approaches the horizon. The average refraction at sunset, or sunrise, is 34 minutes but is dependent on atmospheric conditions. Refraction causes the sun to appear somewhat flattened when near the horizon (about 24 minutes high and 32 minutes wide).

4. Horizon: Plane which is tangent to the earth at the observer's position and perpendicular to the earth's radius at that point. Local terrain often does not permit viewing the entire horizon.

5. Solstice: Days when the sun is at maximum declination (23 degrees 27 minutes) from the celestial equator. This occurs on June 22 (summer solstice) and December 22 (winter solstice).

6. Equinox: Days when the sun crosses the celestial equator (declination zero degrees). The vernal equinox occurs on March 21, and the autumnal equinox occurs on September 23.

HIGH-POWERED REFLECTIVITY



The Boeing Company has successfully constructed a prototype solar concentrator of a type which could be the key to providing an efficient electric power source for long-term space flight.

The concentrator, a 5-foot-diameter dish-shaped mirror, focuses the sun's rays on the cathode of a thermionic converter. This device converts the solar heat into electric power.

The mirror, developed by the Boeing Aero-Space Division's physics technology department, provides both the high reflectivity and precise shape necessary for efficient thermionic converter operation. The reflecting surface is composed of vacuum-deposited layers of silicon monoxide and aluminum. Structural rigidity is maintained by sandwiching ½-inch aluminum honeycomb between layers of epoxy-impregnated fiber glass.

Mirror efficiencies up to 72 per cent—considered superior—have been measured in solar tests. Although the prototype is light in weight (16½ pounds), production models might weigh as little as 8 or 9 pounds.

G. Q. LUMSDEN

Strength and related properties of wood poles —

AN OUTSTANDING ASTM REPORT

A review is presented of the final report of the ASTM Wood Pole Research Program. The Report, massive and thorough, has as its basic purpose the dissemination of reliable knowledge to promote more efficient utilization of wood poles

The long awaited final report of the ASTM (American Society for Testing Materials) Wood Pole Research Program, "Strength and Related Properties of Wood Poles," has been recently issued as a separate ASTM publication. It details the results of what some consider to be the last of the extensive pole-break studies involving full-sized wood pole specimens. The undertaking, the results of which are reported, was one of the most comprehensive co-operative projects ever sponsored by ASTM. It was financed, at an approximate total cost of $300,000, for the most part by the communication and power industries; engineering societies and interested public bodies also contributed. The AIEE was a sponsor through the Engineering Foundation.

The report, in its 182 pages, offers a massive amount of information, including 60 pages of discussion, 31 figures and illustrations, and 82 tables of data covering the testing of some 620 full-sized treated and untreated wood poles of the five major American Standard (ASA approved) species and over 14,000 matched small clear specimens—i.e., free from defects—cut from the poles tested. The basic specimens were class *6-30* foot poles, but some larger and some smaller poles were tested in each species. The pole species studied were Douglas fir, lodgepole pine, southern pine, western larch, and western red cedar. Studies to compare the reliability of the two ASTM standard methods—"machine" and "cantilever" (crib)—were performed on southern pine poles, which include the longleaf, slash, shortleaf, and loblolly species. Both the untreated and the treated poles conformed, with but a few intentional exceptions, to American Standard *05.1-1948*, Specifications and Dimensions for Wood Poles; and all preservative treatments were made to the maximum (severe) conditions allowed under the appropriate species standard of the American Wood-Preserver's Association. A supplementary series of tests was made on longleaf pine to determine the effects of modified steaming and other conditioning, and of treating schedules.

The basic purpose of the program was to promote more efficient utilization of wood poles through more extensive and reliable knowledge of their strength properties and of the factors that affect those properties. The major specific objectives were as follows:

1. To obtain reliable data on strength of untreated and treated poles to provide an accurate design basis for the principal pole species.
2. To determine if tests of small clear specimens can be used in place of full-sized poles to establish fiber stresses for design.
3. To determine how knots, spiral grain, checks, and splits affect pole strength, as a basis for improved specifications.
4. To determine the effect of accepted preservative treating processes on strength of poles and small clear specimens.
5. To compare the reliability of the two standard methods of pole tests and the results obtained from both.

The facts determined and the logical inferences to be drawn from the mass of data obtained convince the reader that all objectives with the exception of item 3 were realized. Reliable data on the strength of treated and untreated poles were obtained, and it is assumed that a more accurate design basis will follow.

The results of the tests made on small clear specimens—a highly economical, quick indoor method as compared with testing full-sized poles—have convinced many that this technique can be used satisfactorily on those domestic pole species not yet subjected to test as full-sized specimens (e.g., Alaska cedar, the spruces, the true firs), or to poles that

A special article recommended for publication by the AIEE Research Committee.

G. Q. Lumsden is supervising timber products engineer with the Bell Telephone Laboratories, Inc., Murray Hill, N. J. He is a member of the ASTM Technical Advisory Committee for the ASTM Wood Pole Research Program.

may from time to time be considered for importation. For this reason many believe this to be the last "big pole-break test." The effects on strength of accepted preservative treating, including the conditioning phase, were studied; and the results on southern pine, at least, loom important to the pole user. Losses in strength, due to the hydrolysis of the wood fibers, are excessive when pine poles are steam conditioned at 259 F. Some consumers have already lowered the maximum allowable steaming temperature to 245 F, and the American Wood-Preservers' Association is currently engaged in revising its standard specification in this regard.

Regarding item 3, there is some discussion in the report of how knots, spiral grain, checks, and splits affect pole strength; but little is offered as a solution to the practical problem which is often the subject of debate between the pole producer, the specification writer, and the user's inspector. For example, we quote, "The matched tests produced little direct information on the effects of knots on the strength of poles"; and "The effect of shakes [sheer failure along the annual growth rings] on the strength of poles is possibly more important [than the effect of checks] though the tests furnished very limited evidence on this point." It is to be appreciated that while 620 full-sized poles were broken, they all conformed, with a few intentional exceptions, to *ASA 05.1-1948*. Therefore, as the defects found were within the specification limits, these limits were not broad enough to permit wide diversity in size or location. As a result, it was impossible for the authors to state with certainty the exact effect of a defect. However, a highly interesting discussion is included concerning the twisting of poles and the relation of twist to spiral grain and to change in moisture content.

Perhaps many will feel that such an extensive test as that reported in the section "Suggested Additional Research" should have provided answers to some of the suggested items. But this sort of testing is expensive and the variables must be kept at a minimum; otherwise the major objectives are either lost sight of or are voided. The subjects for additional research are:

1. Effects on strength from machine shaving (standard today) compared to old hand peeling.
2. Effects from butt soaking in water—to bring the wood above fiber saturation before testing—compared with full-length water soaking of test poles, as done in the current tests.
3. Effects of incising on strength.
4. Practicability of dimensioning poles by specific gravity classes rather than by species.
5. Moisture content of poles in service and effect of drying on strength.

Twenty-one of the more important findings of the ASTM program are listed in the Conclusions. Briefly, these findings include reference to correlation between specific gravity and strength; the difference in modules of rupture between large and small poles; the significant correlation between the strength of untreated poles and untreated small clear specimens taken therefrom; and the successful treating plant experiments with reduced steam-conditioning schedules. Also included are references to the fact that the two standard methods, machine and cantilever, gave essentially similar strength values, except when testing the longer 55-foot poles.

The report concludes with this observation: "The natural wood pole, like the trunk of its parent tree, is a highly efficient structural member." The wood poles standing in lines in the United States, supporting our power and communication systems and totaling over 100 million strong, attest to this.

This document is without a doubt, to date, the greatest single contribution to the knowledge of wood pole strength; it represents an outstanding achievement in co-operative engineering research. Anyone familiar with the work done regularly both by the Forest Products Laboratory and by ASTM will be interested to know that the usual standards of excellence have been more than maintained. We strongly urge that those interested in wood poles as outside plant structures avail themselves of copies.

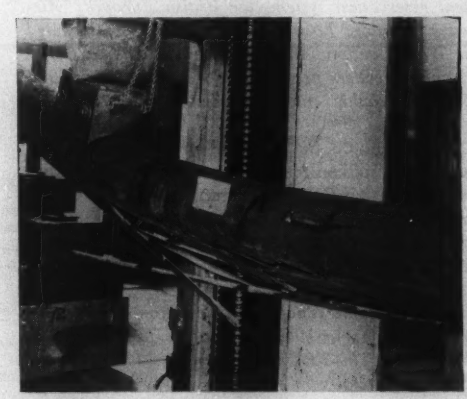


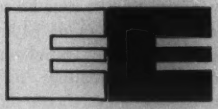
Fig. 1. Failure of 30-foot treated lodgepole pine pole showing moderate compression wrinkles, splintering tension, some horizontal splitting along the grain, and ¾-inch-thick shellout

The report was prepared by L. W. Wood, E. C. O. Erickson, and A. W. Dohr, engineers at the United States Forest Products Laboratory, with the help of L. J. Markwardt and R. P. A. Johnson of ASTM, who were responsible for the project.

REFERENCE

1. Strength and Related Properties of Wood Poles, S. W. Wood, A. W. Dohr. ASTM Report. Obtainable at $5.00 per copy ($4.00 to ASTM members) from American Society for Testing Materials, 1910 Race St., Philadelphia 3, Pa.

Trends...as seen by



Southern California Edison proposes to build a fourth generating unit at a cost of nearly $37 million at its Etiwanda steam-electric station. Construction has been started on a third unit; commercial operation of this one is scheduled for May 1963, and it is planned to have the fourth one ready for operation in October 1963. Total investment in the Etiwanda station will be more than $123 million.

International Telephone and Telegraph Corp. discloses that it has received a $7 million contract *to design and install the first phase of a push-button seat reservation system, for British European Airways, London. Four electronic computers installed at West London Air Terminal will handle 3,000 telephone callers per hour, 280 counter callers, and 500 telegraphic messages regarding reservations.*

Collins Radio Co. has received an Air Force contract for $1.566 million for air-borne transceivers for use in Strategic Air Command aircraft. The radio equipment provides single sideband long-range global communications to be used aboard SAC's jet tankers and long-range jet bombers.

Thompson Ramo Wooldridge's electronic computing systems sales *in 1961 to date are triple the total 1960 sales. The TRW computers, including military and commercial versions, are used for process control in industry, general scientific handling, and production information automation.*

Electrical generating equipment ordered by power systems in this country from domestic sources for the first half of 1961 showed a capacity increase of 28 per cent over the same period last year, according to the Edison Electric Institute.

Contracts totaling more than $2 million *have been awarded to Minneapolis-Honeywell's Boston division by General Dynamics Astronautics to supply rate gyroscopes for use in guidance systems on Atlas missiles. These new gyros automatically check their own state of readiness to perform their basic function of measuring rates of turn in space.*

The U.S. Army has awarded a $4,746,525 contract to Philco Corporation's Communications Systems Division for a microwave and tropospheric scatter system. This will provide voice and teletype transmission by means of techniques on a wide-band radio system for beyond-the-horizon propagation.

Factory sales of television picture tubes *rose in June to end a downward slope that began in April. Sales of receiving tubes also increased in June over the previous month's total. (From the Electronics Industries Association.)*

According to a survey by the Western Electronic Manufacturers Assn., more than half of the electronic manufacturing firms in the West are privately owned corporations and are less than 10 years old. This survey is based on returns from 320 member companies of WEMA. The biggest growth was between 1955 and 1959 when more than a third of the firms were established.

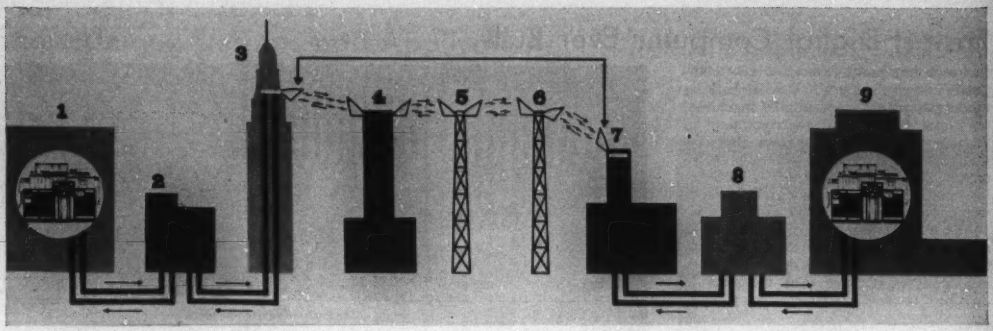
The Soviet Union now produces 50 per cent more electric power in one day *than it did during the entire year of 1920, according to a report on the USSR's electrification projects. Russian plans for 1961 include an addition of 7,800,000 kw to its power capacity.*

Bendix Corp. has received a contract from the U.S. Navy BuShips for five automatic maneuvering control systems for Polaris-firing atomic submarines. Such an automatic system controls the submarine's steering and diving mechanism and contains a solid-state computer which receives signals from the speed, course, and depth instruments.

Domestic and foreign sales of communications equipment *increased about 5 per cent during the first half of 1961 over the same period in 1960, according to the Dept. of Commerce. It is estimated that in 1961 sales will be $3.20 billion with about 30 per cent going to the Government.*

America's electric power industry will provide a $20 million annual market for remote control systems, according to Moore Associates, Inc. As the power companies increase their kilowatt capacity, the need for remote control and telemetering equipment will also increase.

A contract to furnish PCM telemetry ground equipment *for the Nimbus weather satellite in an expected amount of about $1 million has been awarded to Radiation Inc., by the National Aeronautics and Space Administration. Nimbus is expected to perform somewhat the same as NASA's Tiros, but will provide global coverage due to its Earth stabilization and polar orbit.*



From New York City's IBM computer center (1), data flows over cable through West 50th Street central office (2) then to Empire State Building (3). Microwave signals via relay towers in White Plains (4), Pleasantville (5), and Poughquag (6) reach Poughkeepsie central office (7). Finally, signals are transmitted through South Road Labs (8) to Boardman Road location (9)

PROGRESS IN TECHNOLOGY

Fast System Links Computer Centers

Information is sent from one computer to another at a rate 1,000 times faster than human speech with a new communications system announced by International Business Machines Corp., and the New York Telephone Co. The system, connecting IBM data-processing facilities in New York City and Poughkeepsie, N. Y., uses telephone cable, a Bell System microwave radio network, and specially developed IBM 1945 magnetic tape transmission units. These units send information between the two points in either direction or both ways simultaneously at a rate of 15,000 characters per second.

The cable and microwave radio system, 68 air-miles in length, is used by the applied programming group of IBM's Data Systems Div. Applied programming has 200 specialists located in New York City and a slightly larger number in Poughkeepsie. Working at both centers, they create automatic program systems for computers.

Formerly, programming material was sent back and forth by special messenger for processing at either end. An alternate method was to have the programmers visit the machine location, get their jobs processed, and then make the 2-hour return trip to their home office.

Now, programmers at either end of the link can test and revise their programs on computers at the other location by transmitting the appropriate data there and receiving back processed results for evaluation. Output is in the form of punched cards, magnetic tape, or printed copy.

Because of such factors as reduced traveling budget and elimination of some equipment previously needed, a net dollar saving of almost $10,000 a month has been realized due to installation of the system. The total monthly charge for the system is $20,910.

From the IBM computer center at the Time-Life Building in New York City, data flows simultaneously over seven parallel channels through the West 50th Street telephone central office to the phone company's microwave transmitting and receiving center atop the Empire State Building. From there the data goes by microwave radio to the Poughkeepsie telephone central office by way of relay towers in the New York State communities of White Plains, Pleasantville, and Poughquag. At Poughkeepsie it is transmitted by telephone cable through IBM's South Road Labs to the computer center at the company's Boardman Road location.

Floating Nuclear Power Plant Ordered Into Production

Packing enough power to supply the electrical needs of a civilian community of 20,000, a new floating nuclear power plant has been ordered into production by the U. S. Army.

As illustrated below, the nuclear plant will be housed in a reconditioned and rebuilt Liberty Ship, the *Walter F. Perry*. The plant will be designed and built by The Martin Co. The ship will be towed from place to place as needed whenever normal supplies are cut off.

The 10,000-kw system will use a nuclear fuel core less than 4 feet in diameter and only a little more than 3 feet high. Water passing under pressure through the hot core of the reactor transfers the heat to water at lower pressure in a separate "secondary loop." The steam which is produced there turns the blades of a turbine, generating electricity. The core itself will be surrounded by lead and liquid shielding totaling several hundred tons and collision-proof barriers will be provided.

The fuel proposed is uranium dioxide pellets encased in stainless-steel rods half an inch in diameter. The core will contain about 1½ tons of uranium.

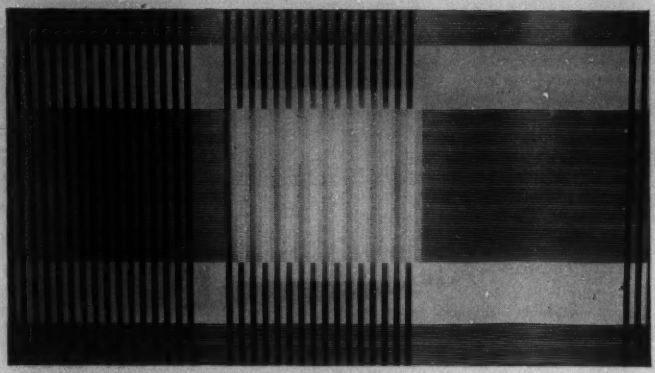
Fastest Digital Computer Ever Built

In every important respect, a new computer known as the FX-1 is a working model for a new generation of machines, ten times faster than any computers in general use today. The new machine now in operation at the Massachusetts Institute of Technology's Lincoln Laboratory is significant also because of the design techniques employed in its construction.

The FX-1 is the first machine with a main memory using thin magnetic films in place of ferrite cores for high-speed, random-access storage. The computer is designed to be a complete, small-scale, general-purpose machine.

In specifying computer speed, two items are of particular interest: (1) the time required to read a computer word out of the memory and to write in a new word (the read-write cycle time) and (2) the speed of the logic circuits, which may be specified by the rate of the timing pulses which govern the operation of these circuits (the clock rate).

The read-write cycle time for the central memory of the FX-1 is 0.3 microsecond. The fastest main memories in machines today have cycle times that generally range from 2 to 12 microseconds. These memories use magnetic cores for storage.



Magnetic-film memory elements (small bright rectangles) are accurately positioned at the intersection of a particular pair of vertical and horizontal conductors on printed-circuit wiring assembly of new computer memory

Usual system uses a plane array of small doughnut-shaped ferrite cores for memory elements in high-speed digital computers

The faster memory in the new computer has a capacity of 256 words of 13 bits each, but provision has been made to increase the initial capacity by a factor of four. The memory employs printed-circuit wiring on a flexible sheet of resin-impregnated glass-fiber cloth. The two halves of the flexible wiring sheet are mounted on stiff backing boards, leaving a flexible hinge between the halves. The arrays of memory elements, deposited on thin glass backing plates, are positioned on the wiring so that each magnetic-film element rests on the intersection of two perpendicular leads on the wiring sheet as illustrated. When all the memory element arrays are in place on the lower half of the wiring sheet, the upper half is folded over to make the completed memory.

The logic circuits in the new computer operate at an effective clock rate of 50 million pulses per second. This speed is made possible by use of high-speed switching transistors developed under subcontract and now in commercial production. Approximately 3,000 transistors are used.

Logic units are packaged in plug-in units that have been designed for compactness; they are also particularly suited to high-frequency operation. Components are mounted on or between two printed-circuit boards that are an integral part of the mechanical framework of the plug-in unit. The plug-in units are mounted in trays that hold up to 20 units each and themselves plug into the computer frame.

About 325 plug-in units of 12 standardized basic types are used. They are mounted in 24 trays of 13 different types. The entire computer, with power supplies, occupies only three relay racks.

Some of the trays used are fabricated by a developmental technique called "plated-circuit" wiring as contrasted with printed-circuit wiring for the plug-in units and conventional point-to-point soldered wiring for most of the trays. The plated-circuit trays employ two layers of etched wiring sandwiched on either side of a central copper ground plane. Wiring of this type behaves like strip transmission line, with uniform impedance characteristics that should simplify and improve circuit performance at high frequencies. Interconnections from one layer of wiring to another are made by plated-through holes rather than by soldering.

Self-Sufficient Power Plant

A portable, self-regulating atomic power plant to generate electricity beneath the surface of the sea or in remote land areas, and requiring no operating personnel, is being developed by General Atomic Div. of General Dynamics Corp. The small "package plant" can operate at generating capacities up to 2,000 electrical kw. On land, the plant might be used to provide electricity for military, weather, or communications stations in polar regions; its undersea version could be a power source for naval defense systems. The self-operating plant will be equipped with homogeneous fuel and moderator elements of uranium-zirconium hydride, having a hydride content of 1.6 to 1.7 hydrogen atoms per zirconium atom, as in those which are used on the company's TRIGA research reactors.

Compact and simple in design, the plant will be capable of transfer from one location to another with a minimum of installation delay. Various modular units may be prepackaged to facilitate rapid assembly and start-up. In some applications the concept may employ thermoelectric elements for the direct conversion of the reactor's heat into electricity. Preliminary investigations have been based on use of either pressurized water or boiling water as the coolant for transfer of the reactor heat.

Thermoelectric Devices Show Unique Designs and Applications

One of the continuing areas of high interest in electrical engineering these days is that of thermoelectricity and its practical applications. Devices are now being announced that show unusual approaches to design as well as novel approaches to applications. A few representative developments are discussed in the following paragraphs.

SUN-POWERED SYSTEMS

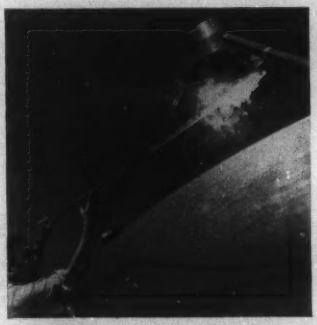
The prototype of a small self-contained 50-watt electric power plant and pumping unit, capable of sustaining individual families or villages by irrigating the land they live on and supplying their household water needs, has been built and tested. Co-operating with the Solar Energy Laboratory of the University of Wisconsin, Westinghouse Electric Corp. built the system. The unit taps the heat energy of sunlight and converts it directly into electricity by means of a thermoelectric generator. The power generated drives an electric motor having a water pump connected directly to it; these are the only moving parts in the system. It is hoped that eventually it may be a factor in offering an improved standard of living to people in underdeveloped areas of the world.

A larger solar-thermoelectric system, now under development, and operated at part power, will have a capability of up to 200 watts of electric power. It will pump enough water from a depth of 20 feet to irrigate approximately 4 acres of land at the rate of 24 inches of water a year, which is about the average annual precipitation in Minneapolis, or in Honolulu. The unit can supply the personal needs of 1,200 people on the basis of 5 gallons of water per person per day.

To provide the stated amount of water, the larger system must operate for only 250 days of the year, 10 hours a day, leaving a safety margin of about one third of the year to provide for cloudy weather, when the generator would not operate.

The system uses an 8-foot saucer-shaped (parabolic) mirror which gathers the sunlight and focuses it on the generator, which is a metal "box" about 8 inches on a side and about 2 inches thick. One face is black, to absorb the heat of the sunlight shining upon it.

Inside the generator, which weighs just over 16 pounds, are 72 thermoelectric elements, or couples, each composed of a "leg" of p-type semiconductor material and one of n-type. Like all thermoelectric materials, they can generate an electrical voltage when heated to a higher temperature on one side than on the other. The 72 couples are connected together in series, and their voltages add together. On its hot side the generator is set at an operating temperature of 840 F (about twice the broiling temperature in a kitchen range); the cool side runs at 150 F.



Sunlight concentrated by the reflector of the Westinghouse solar-thermoelectric power plant is hot enough to ignite a thick piece of wood almost instantly

A technician heats to 2,400 F the all-ceramic thermoelectric generator capable of converting white-hot temperatures into usable electricity. The heat-resistant generator, believed the first to be made of ceramics, is tested by the Army for space age uses. Here the device converts the heat of an electric furnace into 100 volts of electricity

Present estimates place the cost of solar-thermoelectric power high in some areas, but in many others, with improved materials and mass production techniques, its operation is expected to be economically feasible. It would have the advantage of not needing technically trained and experienced personnel in underdeveloped countries.

CERAMICS SHOW PROMISE

A thermoelectric generator made of ceramics, and capable of operating at unusually high temperatures—up to 2,400 F, has been developed for the Army. It produces four times the voltage of thermoelectric generators made of more commonly used materials such as intermetallics.

Output of the new generator is 1,000 to 1,200 microvolts per C, compared with 250 to 300 for intermetallics. A pilot model delivered to the Army's Picatinny Arsenal at Dover, N.J., which supported the development program being carried out by Minneapolis-Honeywell Regulator Co., is designed to deliver 100 volts under no load.

Temperature-measuring instrumentation of a sun-driven thermoelectric power plant being checked out. The thermoelectric generator, located just behind the nose cone at center of reflector takes temperatures of 840 F and turns the heat directly into electricity

It is hoped that the ceramic unit put to use may open the way to obtaining electricity from such "waste heat" as a rocket exhaust, which would destroy presently available thermoelectric generators; also that it might be used to top the energy of a space vehicle nose cone that is superheated by re-entry into the earth's atmosphere.

The new generator uses nickel oxide (a ceramic) with a reference of platinum. The nickel oxide permits operation of hot and cold junctions at higher than normal temperatures. The resistance of the thermopile is therefore reduced, and appreciable currents are supplied.

The generator is made like a cake with 14 layers. Nickel oxide is sprayed on one side of each layer and platinum on the other. The ceramic and metal are then scored with a diamond-bladed circular saw so that they appear to be wrapped around each layer like an unbroken wire. Feltlike ceramic separates the layers. Even nuts and bolts holding the unit together are made of a special ceramic, since ordinary steel would melt under the high operating temperatures.

GAS-WELL PROTECTION

A thermoelectric generator, installed in a remote region of the San Juan Basin, N. Mex., protects a mile-deep gas well, supplying the electric power needed to prevent self-corrosion of the well's steel casing. The technique, known as cathodic protection, keeps the casing from being eaten away through an electrochemical

reaction that occurs spontaneously in metal objects buried in the ground.

The generator taps a small amount of the gas coming from the well, burns it, and converts the heat directly into the electricity that safeguards the well. With no moving parts, it is a simple, trouble-free, static system suited to power production in remote areas where routine maintenance of equipment is especially difficult.

The generator is connected between the 5,000-foot gas well casing and a ground bed consisting of silicon cast-iron anodes packed vertically in a hole 200 feet deep. It reverses the normal flow of current set up by the casing as it chemically reacts with the soil. Thus the easily replaceable ground bed is slowly eaten away instead of the casing itself.

Protection of the well casing is accomplished with about 6 amperes of current at 8 volts d-c. Power is generated at a temperature of 800 F on the hot side of the generator; the cool side operates at 200 F, higher than the boiling point of water at the 6,100-foot elevation at which the generator operates.

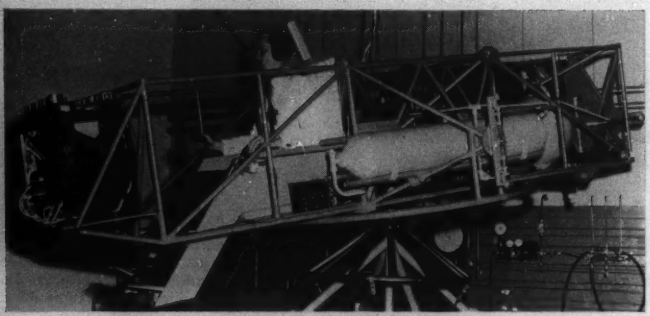
The El Paso Natural Gas Co.'s installation is a co-operative project with Westinghouse Electric Corp., to evaluate the use of this method of power generation for gas well and pipeline protection. The experiment is conducted to determine the feasibility of adopting the technique for cathodic protection in other locations of the Southwest's isolated regions.

ATOMIC GENERATOR

The Atomic Energy Commission has contracted for a model of a first-of-its-kind thermoeléctric generator designed to produce electricity directly from the heat of mixed fission products (MFP), the unrefined waste of nuclear reactors. The MFP fuel to be used in the projected generator is obtained as a by-product from the various power and plutonium-producing reactors and, it is believed, could probably be made available ultimately on a low-cost basis.

The contract represents the second stage in the SNAP development program for such generators, which could be used to power undersea sonar devices, communications equipment, automatic weather stations, navigational beacons, and other equipment in remote areas. General Instrument Corp. is building the working generator model.

Space Topics in the News



Automatic controls evaluation simulator capable of duplicating the problems of controlling a vehicle in space being put through its paces

The space age continues to be a dominant factor in the technical news. The following paragraphs highlight a few of the many recent developments.

■ Chance Vought Corp.'s Astronautics Division has announced a new automatic controls evaluation simulator, called ACES for short, which can duplicate the problems of controlling a vehicle in space as effectively as it can be done here on earth. The simulator is the first of three to be made by Chance Vought. The simulator's only link with its ground base is a 4½-inch steel ball which floats on a column of nitrogen gas pressurized to 120 psi. The floating ball, attached at the platform's center of gravity, permits the delicately balanced simulator to move with such freedom that a coin placed at an extremity is sufficient to cause movement.

■ Radio Corp. of America has developed a precision missile and satellite tracking device with accuracy approaching 5 feet at 2,000 miles. The tracker, developed by RCA's Aerospace Communications and Controls Division, uses the principal of inertial reaction. The high degree of accuracy is accomplished through an interchange of momentum between the tracker mechanism and a rotating flywheel mounted on the tracker. The tracker mass pushes against the flywheel and not against the tracker support, and thus all forces are contained.

■ Aluminum Co. of America has released information to the effect that Ranger I, forerunner of the nation's first spaceship capable of landing instruments safely on the moon, is comprised chiefly of aluminum. The unique craft is scheduled to be launched shortly on a million-mile round trip into space. The 50-day jaunt will test a complex operating system for Ranger spacecraft that will land instrumented packages on the moon.

■ Avco-Everett Research Laboratory's J. E. Hayes and MIT's W. E. Vander Velde report that a clock, an accelerometer, and a shoe-box sized computer are the main components of a satellite landing control system which guarantees landing at a predetermined site. Outlined by Messrs. Hayes and Vander Velde at an American Rocket Society meeting, the proposed system differs from conventional systems in that it indicates its altitude by measuring the density of the atmosphere in which it is traveling.

When recovery is desired, the first step is to determine the exact position of the satellite in relation to the earth. With this information, the time required to initiate a landing at a selected site can easily be calculated. The results of the calculation are relayed to the vehicle in which a highly sensitive accelerometer constantly measures the changing air density to determine the amount of drag needed. As the system is self-correcting, drag is automatically varied to maintain the rate of descent needed to arrive at home base.

■ Lockheed Missiles & Space Company scientist J. Douglas Sailor predicts that the United States can orbit an experimental, high-altitude, 24-hour communications satellite in 18 months. A fully operational system could be established well inside 4 years, Mr. Sailor claims. His remarks were made at a recent meeting of the American Astronautical Society.

■ Garrett Corp's AiResearch Mfg. Co. of Los Angeles has developed an automatic blood-pressure measuring system which will be used to telemeter the blood pressure of an astronaut orbiting the earth. The new system, which also has possible commercial applications, automatically records both the systolic and diastolic blood pressure. It transforms these measurements into an electrical signal for transmitting to ground read-out stations.

■ Martin Co. reports that a pilot on duty in a space vehicle may begin losing alertness after approximately half an hour. The experiment leading to this conclusion is part of a study in pilot vigilance aimed first at understanding human fatigue and providing compensation for it. The ultimate goal is to find ways of stabilizing an astronaut's performance over a long period of time.

Polaris Starter Eliminates Hazard

Missile or launching failures due to faulty electrical connections to sensitive explosive circuits constitute a risk, which may be reduced by a meter which emits a current measured in thousandths of amperes and can fit into a man's hand.

To measure hazardous electric circuits, an extremely low-powered meter developed at Applied Physics Laboratory, The Johns Hopkins University, can test across the most sensitive explosive connections,

Live explosive valve which activates air-eject system for underwater launched Polaris missile shown being checked aboard submarine USS George Washington, SSB(N)598

such as the mechanism which triggers giant rocket motors on the launching pad, without danger of an inadvertent misfire. Measuring resistance on the order of 0.1 to 10,000 ohms, the meter permits last-minute checks on continuity and reliability of these hazardous circuits.

An extremely low current is generated by the light of two small grain-of-wheat incandescent lights shining on a silicon photocell. Bulb and battery are encased in a plastic block and thus isolated from the silicon cell which receives the light of the bulbs through a plexiglass bulkhead. Only the light-generated power from the silicon cell is connected to the meter leads. With this small current across the hazardous circuit, it is possible to check out the most sensitive bridge-wire explosive charges. Current from the cell is so minute that it would not ignite a sensitive charge even if it were amplified 300 times.

For the necessary test immediately prior to firing a small portable or console-mounted meter for final check-out was needed. The meters were used to check out the Polaris missile aboard the *USS George Washington* for the ballistic missile flight last July, also on subsequent submarine and pad firings of the Polaris missile.

At Cape Canaveral the system is used to read continuity from the blockhouse through the explosively actuated components in the missile and back to the blockhouse. It answers such questions, just prior to launch as: Is the squib battery hooked up electrically; Is the umbilical properly mated and does the explosive-actuated circuit go to the firing source? Is the proper resistance available in the bridge wire and firing circuits?; etc.

Klystron Power Output Boosted Four-Fold

Klystrons, a variety of high-power microwave amplifiers, operate on a "bunching" principle by alternately speeding and slowing electrons passing small openings or gaps in a series of cavities inside the tubes. The gaps—usually only a small fraction of an inch across—largely restrict the power output of the tubes, limiting it for the tubes designed for communication systems to approximately 250,000 watts at 1,000 mc or 25,000 watts at 10,000 mc.

By adapting a circuit devised for speeding electrons in atom smashers, Sperry Electronic Tube Div. of Sperry Rand Corp. expects to multiply by four times the output of high-power klystrons; the circuit will also double a system's message-carrying capacity. Advanced design microwave amplifiers are now under test.

The new tubes are expected to increase the effectiveness of satellite-tracing systems or radar astronomy systems mapping stars or the surface of the moon. The amplifiers being tested, called extended interaction klystrons, will hike power by accelerating electrons along "standing waves" generated by a series of circuits inside the tubes. The circuits, or resonators, have an effective length about eight times that of comparable circuits in conventional klystrons. Their use will not increase the physical length of the tubes. The new klystrons will be unusually suited to liquid cooling, which will dissipate much power-robbing heat generated by the operation of the tubes.

Unique circuit in an advanced microwave power amplifier is adjusted for test

New Look for Typewriters

International Business Machines' new electric typewriter Selectric replaces the conventional type bars with a single sphere-shaped element bearing all the usual characters. In the conventional typewriter, the paper-carrying component moves; in the Selectric the sphere moves back and forth across the paper and is rocked against the ribbon and paper as it prints; thus the type bar is not needed. In addition, a "selective stroke storage system" incorporated in the new machine increases the typist's speed and accuracy. If two characters are struck nearly simultaneously, (on the conventional typewriter resulting in jammed type bars), only the first is typed, while the system automatically stores the other for a split second and then types it.

For billing, personal and general correspondence, and script typing, the sphere-shaped element may be easily removed by the typist and replaced with another type style. Instead of ribbon spools a ribbon cartridge containing two spools, side by side, is mounted on the carrier. The typist lifts the cartridge off the carrier, and snaps a new one in, without the need for touching the ribbon itself. Ribbons in eight colors are available.

The stationary carriage reduces desk space requirements for the machine, and eliminates vibration and carriage-return "jolt." There is no change in the keyboard. The sizes are: one for paper up to 11 inches wide (cost $395), and the other for paper widths up to 15½ inches (cost $445).

Arctic Weather Research

An automatic data system for measuring and recording information on Arctic weather is being designed by Datex Corporation for use by the U.S. Army Signal Research and Development Laboratory in Greenland. The temperature and radiation integrating system equipment will be used in research on weather in this zone which holds clues to world-wide weather conditions.

The 20-channel system provides and receives 8 differential temperature signals, 2 absolute temperature signals, and 10 radiation signals. Each of the input variables will be measured 100 times every hour. To obtain average values over a 1-hour period, the 100 instantaneous measurements of each variable will be accumulated and the sums divided by 100. The data, recorded on a punched tape, may then be analyzed by a computer.

Smog Measured

For determining dangerous levels of smog, a new instrument is being field tested on the detection of sulfur dioxide in the atmosphere for the State of California Department of Public Health.

Tracerlab has developed, under contract from the Office of Isotope Development of the Atomic Energy Commission, an air pollution monitor which operates by drawing the air to be analyzed into a detection unit. The air then passes through a small tube containing a special radioactive chemical reagent.

As the contaminating gas reacts with the reagent, an amount of radioactivity is released which is directly proportional to the amount of contaminant present. The radioactive gas is then carried into a shielded volume where its concentration is measured by means of a geiger tube. The number of pulses from the tube are indicative of the amount of contamination present. Results are read on a meter calibrated to read directly in parts per million and parts per billion.

Atomic Automatic Weather Station

On bleak and uninhabited Axel Heiberg Island, 750 miles from the North Pole, the first atomic-powered weather station has been installed. The automatic recording and transmitting unit, built by the Nuclear Division of the Martin Company under contract with the Atomic Energy Commission, is an unmanned radioisotope-fueled station. Its function is to fill the gap in the weather network between two manned outposts at Resolute Bay and Eureka; the data will be made available to all nations.

The weather station's atomic generator uses no moving parts. Heat produced spontaneously by the radioactive decay of strontium-90 is converted directly into electricity by thermocouples. It is intended to operate for 2 years without any maintenance or refueling, and is capable of transmitting over distances of 1,500 miles.

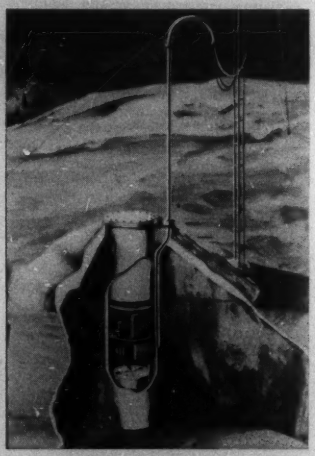
The strontium-90 is locked chemically within a stable, insoluble compound and encapsulated in several layers of corrosion-resistant shielding for added protection. The generator is designed to survive even a plane crash without releasing fuel. The insoluble fuel cannot be absorbed by living organisms. Station and power source are housed in a cylindrical, insulated container, approximately 8 feet long, with the lower 5 feet buried in the permanently frozen ground.

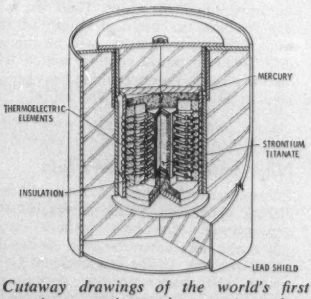
Reliable and rugged meteorological instruments — anemometer, thermometer, and barometer — mounted as integral parts of the station will measure wind direction and speed, temperature, and barometric pressure. Readings are fed into a data-processing system and emerge ready to go directly into the radio transmitter, which in turn will relay them every 3 hours to the receiving stations at Resolute and Alert.

Because of no moving parts, the system sustains no wear as a result of operation; and long-term, maintenance-free reliability is possible. The "dumping" of excess heat from the generator is regulated to keep components within a constant narrow-temperature range.

In the operating generator, the fuel pellets are encased in several layers of an alloy called Hastelloy-C, which would take centuries to corrode, even if immersed in the ocean. Radiation from strontium-90 in the working generator could be blocked by a variety of materials. In the first unit, more than ¾ ton of lead has been used. Final protection for the whole generator is an outer cladding of stainless steel, with the whole generator designed so sturdily that it could even survive a plane crash or explosion without releasing its fuel.

Close co-operation between the U.S. Weather Bureau and the Canadian Department of Transport prompted the suggestion by the latter's Meteorological Service that the station's site for trial use be in the Canadian Artic.





Cutaway drawings of the world's first atomic-powered weather station show its installation in a remote and barren area north of Canada. The atomic generator at the bottom of the cylinder, deriving power from pellets of strontium-90 via a thermoelectric conversion system, operates the electronic instrumentation and automatically transmits weather data every 3 hours

Medical Conference News From The Waldorf

In July, scientists observed a realistic working model of the heart, on view at the Fourth International Congress on Medical Electronics at the Waldorf-Astoria in New York. The model, weighing 392 pounds, showed pulsating tubes undergoing "fatigue" and wearing out. In the process the tubes were seen to become twisted and distorted into shapes resembling those of living arteries hardening with age—a condition often associated with coronary heart disease. The remarkable demonstration applied the laws of electricity to the flow of blood. The inventor, British Royal Air Force Group Captain J. E. Malcolm, had noticed similarities between the action of the heart and the action of the electrical equipment known as the klystron; he first built a hydraulic oscillator on the klystron principle. The oscillator, also on view at the New York Congress, runs on fluid, including blood; from this the working model was developed.

FUNCTIONING UNDER STRESS

Another Fourth International Medical Conference subject was an electronic "brain" which has been applied experimentally in attaining evaluation of human capability to function under stress. Initial results show that the tests may be applied to civilian as well as military use. In civilian life, accident-prone individuals may be weeded out from among applicants for drivers' licenses. The driver would be tested behind the wheel of an automobile mock-up with a motion picture of varying highway conditions in place of the windshield. Electroencephalographic (EEG) signals from the subject's brain, transmitted to the electronic computer would be compared with existing standards of acceptable reaction. Spacemen and commercial airline pilots could be tested before and after flights.

For Radio Corporation of America, a group of volunteer subjects aged 20 to 45 were observed during periods of sleeplessness ranging to 72 consecutive hours, interspersed with various forms of visual and other stimulation. Signals from the brain were converted to digital signals acceptable to an RCA *301* electronic data-processing system. The computer's "memory" previously had been stored with factors having a bearing on the alertness readings.

The waveforms monitored during the 72-hour period were related to a scale of scores ranging from zero to 20, reflecting human alertness or capability to function. On the basis of the EEG waveforms the computer pointed to the corresponding alertness score of the subject under test. The tests are being conducted by RCA's Electronic Data Processing Division.

SCIENTIFIC OVARIAN RESEARCH

Also described at the Medical Conference at the Waldorf was a technique using minute passive radio "pills," called "endoradiosondes," which are implanted permanently in the bodies of monkeys.

Experiments are aimed at determining (1) physical changes occurring at ovulation—the recurring periodic production and expulsion of the egg, or ovum, from the ovary (just when ovulation is about to occur or has occurred) and (2) for continuously monitoring the functions of the ovary. Miniature electronic devices fixed on and near the ovaries are designed to measure physical changes and transmit the measurements to a sensitive radio receiver outside the body.

Developed by RCA specialists, the pills consist of a speck of temperature-sensitive ceramic material, about half the size of a split pea, which is inserted in the ovary or fixed to its surface; and an inductor unit, consisting of a small piece of electromagnetic material wrapped in a coil of wire, attached to the side wall of the pelvis, and connected by wires to the minute sensing element.

The implanted system sends out a radio signal whenever the inductor unit is triggered by a signal of approximately the same radio frequency sent into the body from the outside. This takes place in the way that a tuning fork vibrates and emits sound when it is snapped by a finger, but the product is a radio signal rather than a sound. Techniques have been developed to permit motion picture photography inside the area under study, as a means of checking the position of the radio pills and relating the transmitted signals to the physical behavior of the ovary.

In the initial stage of a 3-year program supported by the National Institutes of Health, the experiments are being performed at the Department of Gynecology and Obstetrics of the University of Pennsylvania Graduate School of Medicine in Philadelphia.

HEART ACTION RECORDED

An experimental radiocardiograph that records heart action without the use of wire connections was in action at the Fourth International. By means of this instrument, hospital patients may have their temperature, pulse, and breathing under constant watch from one central point on each hospital floor. The concept is a simple "building-block" system of small electronic measuring and radio-transmitting devices. For demonstration, this Radio Corporation of America radiocardiograph used a sensitive transmitter only slightly larger than a lump of sugar. Placed against the skin at the fingertips, on the arm, or elsewhere, the miniature unit can detect heart action from the associated electrical changes in the body; it transmits the information to a recording antenna elsewhere in the room for display as a visible cardiogram on a viewing tube or an inked pattern on recording paper. Thus the need for wire connections from patient to recorder is eliminated.

Similar miniaturized telemetering transmitters can now be developed to pick up and transmit a variety of routine hospital measurements, including temperature and rate of breathing as well as heart action. Built into minute packages which can be worn by patients, the devices can keep a constant check on these functions and transmit the information to an antenna installed in a room or ward. From the antenna, the data may be carried by wires to a central location for display to a floor nurse or a doctor.

The first application of such a system, now technically feasible, the RCA scientists said, would probably be in surgical recovery rooms where continuous patient monitoring is essential.

"TONING IN" ON HEART TISSUE

In open heart surgery the chance of surgically induced heart block is an important factor, which can be minimized if not eliminated by an electronic instrument for precisely locating vital heart tissue. Medtronic, Inc., Minneapolis, Minn., announces the Medtronic conduction system locator (designed to work on the arrested heart as well as the beating heart), a long, pencil-like depth probe affixed to a "tone box." The tone changes pitch when the probe is passed back and forth across the ventricular septum, and contact is made with the vital heart tissue—in medical parlance, the "bundle of His." The bundle's location is traced with an accuracy of 1 millimeter. Surface effects from blood, saline, etc., are eliminated, and detection of the bundle is possible to depths of 4 millimeters. The probe is autoclavable. Earphones for the surgeon concentrate specifically on the tone. A meter on the tone box zeros the instrument before use, and indicates the changes in relative conductance of the tissue. Zeroing is done by placing the probe on tissue away from the bundle and adjusting zero indication on the meter. The instrument utilizes a transistor circuit and a rechargeable battery.

Digital Computer Directs Automatic Dispatching Control System

Placed in operation recently by Philadelphia Electric Company is the first digital computer directed control system that assigns to turbine generators automatically and continuously the amount of power each is to supply at minimum incremental cost. The utility and Minneapolis-Honeywell Regulator Company collaborated in development of the system.

By the end of the year, most of the 34 generating units at 9 power stations—27 driven by steam turbines and, at Conowingo dam on the Susquehanna River in Maryland, 7 by water—will be under automatic load control of the computer-directed system.

BENEFITS DERIVED

Philadelphia Electric expects the control system to provide these benefits:

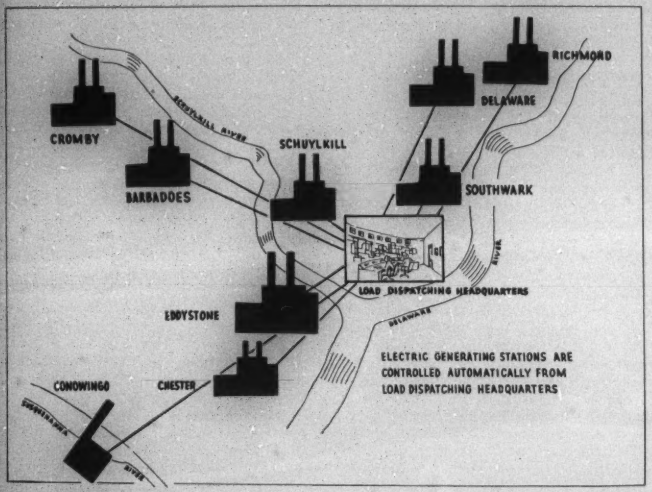
1. Economical incremental loading of controlled units.
2. Improved response of generating units to load changes.
3. Continuous determination of system transmission losses.
4. Cost data for billing purposes on the amount of power exchanged between the company and the Pennsylvania-New Jersey-Maryland Interconnection (a 12-utility power pool serving more than 15 million people) of which it is a member.
5. Off-line systems studies and calculations, including maintenance scheduling.

SYSTEM OPERATION

Heart of the automatic dispatching system is the Honeywell 290 computer. Other basic parts are: individual load-frequency control systems for each of 15 separate command channels; peripheral equipment linking the computer to the control system, including a console from which power directors operate and supervise the power system; and telemetering equipment that transmits computer commands

In making allocations, computer bases calculations in incremental production cost curves, performance characteristics of 34 controlled generating units, transmission losses, and other information

Nerve center of dispatch system is this control console from which power directors operate and supervise loading of generating units at minimum incremental cost of operation



Philadelphia Electric Co.'s nine power stations will be under automatic load control of the computer-directed system by the end of this year

to the nine generating stations. All except the generator controls are based at the utility's dispatching headquarters in mid-city Philadelphia.

Once the total generation level is determined and initial allocations are made to controlled generating units, the computer samples the desired steam generation every 10 seconds. It then calculates new economic allocations and sequentially sets these values on control amplifiers to obtain the most economic loading. These differential amplifiers hold an output constant, thus acting as fail-safe memory devices if control is interrupted. The amplifiers also control governor motor actuators so that generators are loaded in accordance with the computer's command signals.

In making economic dispatch calculations, the computer bases its computations on incremental production cost curves, fuel costs, performance characteristics of each controlled generating units, and incremental transmission losses, all programmed information, and "reads" various input variables. These variables, which enable the computer to synchronize itself with system conditions, include total assigned steam generation, manually controlled steam units, hydro generation, Interconnection tie-line power flow, and steam turbine generating units available for allocation.

During each hour, the computer, again making use of various input variables and integrating as well the actual total generation and net power exchanged with Interconnection, makes cost determinations for intercompany billing purposes. These computations are punched on paper tape for further accounting use.

At each station under computer control, the electronic equipment consists of a small console from which high and low limits of generating units and rate of change of generation can be set, and remote relay racks. These racks contain control amplifiers, governor motor actuators, and rate limiters that monitor generator output and prevent actuators from moving units too rapidly.

The system makes use of solid-state design. The only moving parts are relays. No motors, servos, slide wires, or vacuum tubes are used.

NEW LIBRARY BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ELECTRICAL ESTIMATING. by Ray Ashley. Third Edition. McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y., 1961. 437 pages, 7½ by 10 inches, bound. $12.50. This volume ranges in its coverage from the selection and training of electrical estimators to the proper use of estimating tools, the cost of prelminary estimates, and the preparation of final bid shuts. Included are sample estimates, methods of checking estimates, and the preparation of labor-cost units. It also shows how to figure markups and provides information useful in solving problems relating to appraisal, cost accounting, and job scheduling.

INTRODUCTION TO ELECTRICAL ENGINEERING SCIENCE. By H. A. Foecke. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1961. 778 pages, 6¼ by 9¼ inches, bound. $15.65. The author approaches the field of electrical engineering as an orderly and rigorous structure based on a relatively small number of basic principles. Significant features of the text include an early discussion of vacuum tubes, gas tubes, and transistors, which permits an integration of problems in circuit analysis; a consideration of the dynamic response of circuits and machines prior to a consideration of their respective steady-state behaviors; and deferring the study of electric circuit behavior until after the characteristics of all types of circuit elements have been carefully developed.

ADVANCES IN ELECTRONICS AND ELECTRON PHYSICS, VOLUME 14. Edited by L. Marton. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1961. 341 pages, 6¼ by 9¼ inches, bound. $11. Current research is surveyed in such areas as strong focusing lenses, hydrogen thyratrons, Cerenkov radiation at microwave frequencies, high-power axial-beam tubes, the electron as a chemical entity, and problems of photoconductivity.

PROGRESS IN DIELECTRICS, VOLUME 3. Edited by J. B. Birks. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961. 292 pages, 6¼ by 9¾ inches, bound. $10. Following a review of the important microwave applications of dielectrics as waveguides and as antennas, this volume continues wtih discussions of dielectric polarization and absorption, the dielectric properties of water, dielectric absorption in solids, and recent developments in cable insulation in the United States. It concludes with a comprehensive, critical survey of the theory of dielectric breakdown in solids.

OPTIMUM USE OF ENGINEERING TALENT. Edited by J. W. Blood. American Management Association, 1515 Broadway, New York 36, N. Y., 1961. 416 pages, 6¼ by 9½ inches, bound. $9. Various phases of effective engineering management are discussed, from the basic objectives, responsibilities, and organization of the engineering division to the recruiting and selection, compensation, supervision, professional development, and evaluation of engineers. A special group of case studies describe the engineering organizations of IBM, Carborundum, and Convair.

TRANSISTORS AND ACTIVE CIRCUITS. By J. G. Lincill and J. F. Gibbons. McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y., 1961. 515 pages, 6¼ by 9¼ inches, bound. $14.50. The fundamental problems encountered in active circuits are discussed, particularly those circuits in which the active element is the

transistor. The model concept is stressed throughout, with emphasis placed on the selection of the most appropriate model according to the requirements of the particular problem. The text is divided into three parts dealing with the physics of semiconductors, two-port network theory, and transistor circuits. The last part discusses a representative group of transistor circuits, including both the linear amplifier and pulse circuits of the nonregenerative and regenerative varieties.

OPERATIONAL ELECTRICITY. By C. I. Hubert. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961. 530 pages, 6 by 9¼ inches, bound. $8.50. This is an integrated study of a-c and d-c circuits and machines, in which direct current is treated as the special case of alternating current at a frequency of zero cycles per second. The electric circuit is presented for the general case and, when applicable, the discussions include the zero-cycle system. Wherever possible, the author has injected applicable operating techniques in addition to treatments of the parallel operation of generators, the selection and application of motors and controls, magnetic controllers, and regulators.

ANTENNA ENGINEERING HANDBOOK. Edited by Henry Jasik. McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y., 1961. Various pagings, 6¼ by 9¼ inches, bound. $22. The Properties and design relationships of antennas, as well as their use in various array arrangements, are presented in a comprehensive fashion. The emphasis is on practical design application, and recent advances are covered in detail, such as frequency, and the following types of antennas: independent, surface-wave, scanning, and radio-telescope. Special topics associated with antennas, such as transmission lines, impedance matching and broadbanding, radome problems, and propagation problems, are also included.

STATIC RELAYS FOR ELECTRONIC CIRCUITS. Edited by Richard F. Blake. Engineering Publishers, P. O. Box 2, Elizabeth, N. J., 1961. 198 pages, 6¼ by 9¼ inches, bound. $7. This is a collection of papers discussing the basic design, properties, characteristics, and application factors of static relays. Emphasis is placed on the unusual properties of static relays which makes them suitable for applications which are beyond the capabilities of conventional electromechanical relays. In some instances case histories showing how static relays have been used in commercial equipment are also given.

SEMICONDUCTOR DEVICES AND APPLICATIONS. By R. A. Greiner. McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y., 1961. 493 pages, 6¼ by 9¼ inches, bound. $12.50. The physical principles which underlie the operating characteristics of semiconductor devices are described at length. The characteristics and parameters of these devices are then derived and applied to a variety of small and large signal circuits. A particularly detailed description is given of switching effects and switching circuits because of the wide field of application in this area. Many completely worked out examples are included.

THE PHYSICAL THEORY OF TRANSISTORS. By L. B. Valdes. McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y., 1961. 370 pages, 6¼ by 9¼ inches, bound. $10.50. The theory of diodes and transistors is presented with primary emphasis on the internal structure of these devices. To this end, the flow of current through semiconductor materials is analyzed and the relationships between the electrical characteristics of transistors and their physical structure are derived. The text, divided into three parts, provides, first, introductory material to unify the various concepts making up the study of transistors; second, establishes the physical concepts and develops the mathematical tools required to formulate the theory of semiconductor devices; and third, analyzes specific device structures.

MICROWAVE FERRITES. By P. J. B. Clarricoats. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961. 260 pages, 6¼ by 10 inches, bound. $8. Following a description of the general properties of ferrites and their behavior at microwave frequencies, the author discusses loss mechanisms in ferrites and propagation through ferrites in ferrite-loaded waveguides. He concludes with the design of specific waveguide components including the isolator, the circulator, variable attenuators and switches, and variable phase shifters.

INDUSTRIAL CONTROL ELECTRONICS. By Matthew Mandl. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1961. 344 pages, 6¼ by 9¼ inches, bound. $10.65. The fundamental principles of industrial electronic circuitry are presented in a practical fashion: First, a review of basic material, control signals, solid-state devices, amplifiers, and oscillators is given. This lays the groundwork for the more advanced topics, which include reactors, generators, power supplies, transducers, gating and switching, motors, servomechanisms, and magnetic amplifiers. Finally, commercial equipment as used in counting and indicating, control systems, and computer systems, is briefly described.

HALBLEITER-BAUELEMENTE IN DER MESSTECHNIK. VDE-Verlag G.m.b.H., Berlin, Germany, 1961. 213 pages, 7 by 9½ inches, bound. D.M.$18. A group of twelve papers on semiconductors in measurement technology: one introductory; two on semiconductor diodes; four on transistors as amplifiers, switching devices, etc.; three on thermoelectric, mechanical-electric, and optical-electric transducers; and two dealing with the application of the Hall effect.

FORTSCHRITTE DER HOCHFREQUENZTECHNIK, VOLUME 5. Edited by M. Strutt and F. Vilbig. Akademische Verlagsgesellschaft m.b.H., Frankfurt am Main, Germany, 1960. 412 pages, 6¼ by 9¼ inches, bound. No price given. A group of eight articles reviewing recent developments in various areas of high-frequency technology: low reflecting absorbers for electromagnetic waves; millimeter-wave tubes; the problem of electron motion in electric and magnetic fields, taking space charge into account; charge storage tubes; systems for speech compression; channel capacity utilization of TV relay links; recent advances in digital communication; recent developments in the field of semiconductor devices for high frequency. Five articles are in English and three in German, with both English and German summaries and reference lists.

BRITISH MINIATURE ELECTRONIC COMPONENTS AND ASSEMBLIES DATA ANNUAL, 1961-62. Edited by G. W. A. Dummer and J. M. Robertson. Pergamon Press, 122 E. 55 St., New York 22, N. Y., 1961. 479 pages, 8½ by 11¼ inches, bound, $15. This first volume in an annual series contains concise data on a wide variety of miniature components. In addition to technical data on each miniature component, information is given on the effects of potting resins, nuclear radiation, temperature overload, vibration, etc. Components included range in size up to about one cubic inch. Only those components manufactured or assembled in the United Kingdom are included.

SOLID STATE PHYSICS, VOLUME 10. Edited by Frederick Seitz and David Turnbull. Academic Press, 111 Fifth Ave., New York 3, N. Y., 1960. 516 pages, 6¼ by 9¼ inches, bound. $12. Five articles are presented in this volume. The first describes how positron annihilation studies can yield information about certain solid state problems; the second reviews intermetallic diffusion phenomena and their interpretation; a discussion follows of the theory for electron-excess color centers in alkali halide crystals. The two concluding articles consider the continuum theory of stationary dislocations and some theoretical aspects of superconductivity.

LIBRARY SERVICES

Engineering Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, UEC, 345 East 47 Street, New York 17, N. Y.

DEMINERALIZATION BY ELECTRODIALYSIS. Edited by J. R. Wilson. Butterworths, Inc., 7235 Wisconsin Ave., Washington 14, D.C., 1960. 378 pages, 5¾ by 8¾ inches, bound. $14. Research in the application of the electrodialysis process for the commercial production of partially demineralized water from brackish and sea waters is summarized. The broad outlines of the electrodialysis process are

presented, and followed by a discussion of the physical chemistry and the determination of the mechanical and electromechanical properties of ion-selective membranes. A separate chapter is devoted to experimental work carried out in developing parchment-based membranes. The book concludes with the factors to be considered in the design of an electrodialysis plant, as well as the actual design and operation of a plant which processes 2.4 million gallons per day.

PLASMAS AND CONTROLLED FUSION. By D. J. Rose and Melville Clark, Jr. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961. 493 pages, 6 by 9¼ inches, bound. $10.75. The major portion of this work is concerned with plasma physics, hydromagnetics, and elementary gaseous electronics in association with transport and electromagnetic theories. The last four chapters deal more specifically with the controlled fusion problem, including experimental and theoretical approaches, and methods of eventual energy recovery. Problems and references are attached to each separate chapter.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of Electrical Engineering. *All inquiries should be addressed to the issuers.*

COMPUTER CHARACTERISTICS CHART. This new chart has been updated to include latest developments in the field of electronic data processing. Facts regarding 61 general purpose, American-built computer systems have been incorporated, including seven newly announced computers and some modifications stemming from hardware changes. A new column shows the availability date of COBOL-like and ALGOL-like compiler programs. Annual subscriptions are available in pocket-size plastic covered booklets or on six 8½- by 11-inch sheets at $5; single issues may be had for $1.50, from N. R. Statland, Charles W. Adams Associates, Inc., 142 the Great Road, Bedford, Mass.

ROCKET PROPULSION TECHNOLOGY. Vol. I. This book comprises the proceedings of the Rocket Propulsion Symposium held at Cranfield, England, early this year, and contains all formal discussions held, as well as papers read. Reliability and controllability in rocket engines are the chief topics. Six papers on controllability describe recent work in this area, including special difficulties arising with large engines using liquid oxygen. Reliability is discussed in a group of papers under the headings of measurement and interpretation, design and development, solid propellants, charge inspection, and high-strength motor cases. Papers in other areas are also presented, many of them describing new experimental and test techniques. The 370-page book is priced at $12, and is available from Plenum Press, Inc., 227 W. 17 St., New York 11, N. Y.

HANDBOOK OF CHEMISTRY AND PHYSICS. 43rd Edition, by Hodgman, Weast, and Selby. This 3,647-page handbook is intended to provide a 1-source reference for users of mathematics, physics, and chemistry. New material has been added, and new tables of general use include the Color Code for Electrical Resistors and Sound Velocity in water above 212 F. Revised and expanded data include thermal neutron cross sections, general value of physical constants, and masses and mean lives of elementary particles. Priced at $12, the handbook is available from The Chemical Rubber Co., 2310 Superior Ave., Cleveland 14, Ohio.

TRIG, LOG, ANTILOG AND LOG OF TRIG FUNCTIONS. This addition to the "vest-pocket library" gives 6-place tables of trigonometrical functions, logarithms, antilogarithms, and logarithmic trigonometrical functions. Among other tables included are proportional parts for multiples of 5 seconds and 8-place logarithms of numbers required for compound interest calculations. The book is priced at $1.00 from Ottenheimer Publishers, Inc., Baltimore 15, Md.

NATIONAL FIRE PROTECTION ASSOCIATION. Three new publications on controlling fire hazards have been issued by the NFPA. *Static Electricity, NFPA no. 77M, 60 pages, $1,* is a complete revision of the previous publication on this subject. This edition discusses the theories of static electricity generation and dissipation, and applies them to the handling and use of flammable liquids, gases, dusts and fibers, including certain specialized industrial and commercial applications. *Mobile Homes and Travel Trailers, NFPA no. 501B, 27 pages, 60¢,* is a revision of the Association's guide for safe electrical wiring, heating equipment, piping, and fuel storage in mobile homes and travel trailers. *Essential Hospital Electrical Service, NFPA no. 76-TR, 23 pages, 50¢,* is a tentative standard for the installation of emergency electric systems in hospitals. The preliminary standard has been printed to permit interested persons to review the recommendations. All three publications may be ordered from the NFPA, 60 Batterymarch St., Boston 10, Mass.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Supplements on instruments and apparatus to the Power Test Code are now available from the ASME. *Temperature Measurement* (part 3 of the series) replaces a segment of the test codes originally published during the period 1931-1945, and since made obsolete by changes in the technology of temperature measurement. The 119-page volume includes nine chapters on such topics as instrument calibration, various kinds of thermometers, and optical pyrometers; $5.50. *Measurement of Shaft Horsepower* (part 7) is a new addition to the series which describes various types of instruments and methods of measurement likely to be prescribed in the Power Test Codes. It includes sections on the limits and sources of error, calibration, and direct and indirect methods of measuring shaft horsepower. *Measurement of Rotary Speed* (part 13) describes instruments and methods used to measure rotary speed or slip, and gives information on the characteristics and limitations of commercially available instruments used in the testing of rotating machinery; $2. The supplements may be obtained from the ASME Order Dept., 345 E. 47 St., New York 17, N. Y.

AMERICAN STANDARDS ASSOCIATION. *The American Standard Specifications for: Rectangular and Square Bare Aluminum Wire for Electrical Conductors,* C7.43-1960; *Concentric-Lay-Stranded Copper Conductors, Hard, Medium or Soft,* C7.8-1960; *Rolled Aluminum Rods (EC Grade) for Electrical Purposes,* C7.21-1960; *American Standard Method for Sampling Electrical Insulating Oils,* C59.21-1961; *American Standard Methods of Test for Resistivity of Electrical Conductor Materials,* C7.24-1960. These standards have been developed and published by the American Society for Testing Materials, and approved by the ASA. Copies are available at 30¢ each from Jack Eden, American Standards Assn., 10 E. 40 St., New York 16, N. Y.

HOW TO DESIGN AND SPECIFY PRINTED CIRCUITS. This publication is printed in a paper-bound version to fill the need for greater distribution. Providing information for users of printed circuitry, it is priced at $1 per copy, and is available from the Institute of Printed Circuits, 27 E. Monroe St., Chicago 3, Ill.

SAFE OPERATION OF CRITICAL ASSEMBLIES AND RESEARCH REACTORS. This manual was prepared by the International Atomic Energy Agency as no. 4 in its "Safety Series," to meet the need for a manual of practices in the safe operation of critical assemblies and research reactors. The book is intended primarily for technical workers, but also includes suggestions for the organization and administration of reactor operations. Priced at $1.50, the 104-page book is available from the National Agency for International Publications, Inc., 801 Third Ave., New York 22, N. Y.

CURRENT TRENDS IN SCIENTIFIC RESEARCH. This book, compiled by Prof. Pierre Auger, is primarily a survey of the principal lines along which scientific research is being undertaken. An introduction by Prof. Auger sets forth his belief that ". . . all progress in the applied sciences leads ultimately to man." The work is

intended to help the scientist or research worker in his increasingly difficult task of keeping abreast of today's rapid developments in his field. The survey covers all the countries of the world, and each scientific field, from pure mathematics to food and agricultural sciences. Applied sciences in which current research is included are nuclear energy, electric power transmission, telecommunications, and many others. Published by UNESCO and priced at $6.45, the 245-page book is available from the Columbia University Press, 2960 Broadway, New York 27, N.Y.

IPCEA-NEMA STANDARD. *IPCEA-NEMA Standards Publication for Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy* has been completed by the cooperating organizations, Insulated Power Cable Engineers Association and National Electrical Manufacturers Association. The standards included apply to material, construction, and testing of thermoplastic wire and cable for use under normal conditions of electrical installation, whether indoors, aerial, underground, or submarine. Thermoplastic insulations and jackets dealt with are compounds made from polyvinyl chloride, the copolymer of vinyl chloride and vinyl acetate, and polyethylene, and requirements are given for domestic, commercial, and industrial applications up to 15,000 volts. Data also included on some specific types of wire and cable. Priced at $3.50, the standard is available from the National Electrical Manufacturers Association, 155 E. 44 St., New York 17, N. Y.

BASIC RADIO. This 6-volume series by Marvin Tepper presents a complete pictured-text course in basic radio. The course covers fundamentals of radio communications, equipment, electricity, and magnetism. The paperback volumes may be purchased as a complete set or singly at the following prices: *Vol. 1, D-C Electricity, 144 pages, $2.70; Vol. 2, A-C Electricity, 144 pages, $2.70; Vol. 3, Electronic Tube Circuits, 144 pages, $2.70; Vol. 4, AM and FM Receivers, 128 pages, $2.50; Vol. 5, Transistors, 72 pages, $1.90; Vol. 6, AM and FM Transmitters, 144 pages, $2.70; six-volume set, 776 pages, $13.85; (single cloth binding, 776 pages, $14.85).* John F. Rider, Publisher, 116 W. 14 St., New York, 11, N. Y.

ASM METALS HANDBOOK. Vol. 1. Eighth Edition. *Properties and Selection of Metals.* This new 1,300-page handbook of the American Society for Metals contains 430 data compilations for important alloys, more than 100 articles, and 6,707 illustrations. It is intended specifically as a reference volume for engineers, production planners, and designers. Priced at $30, it is available from the AMS, Metals Handbook Dept., Metals Park, Novelty, Ohio.

GENERAL AVIATION INSPECTION AIDS. The Federal Aviation Agency compiles reports of malfunctioning and defective airplane parts to make up this publication. The information contained is intended to inform the general aviation public of service experience and, where pertinent, to direct attention to the manufacturer's recommended corrective measures. An initial summary of items from 1960 reports will be followed by eleven monthly supplements containing additional information. The summary and supplements will be available on a single subscription from G. C. Prill, Director, Flight Standards Service, Federal Aviation Agency, Washington 25, D.C., at $1.25 per subscription.

ENGINEERING INDEX. The 1960 bound Engineering Index is ready for distribution. The 1,759-page volume covers all applications of engineering methods and concepts to industry, agriculture, and mining. It includes lists of publications reviewed and authors, and a subject index of more than 34,000 annotations. The Engineering Index annotates and indexes selectively, on the basis of engineering significance, the available current technical periodicals received by the Engineering Societies Library, as well as papers of conferences and symposia, separate and nonserial publications of various kinds, and selected books. In all, over 3,300 publications are received from 42 countries and in 22 languages. Divided into 249 "field of interest" divisions, the service is issued both on 3- by 5-inch library cards mailed weekly to all subscribers, and in a bound volume 7 by 10 inches, which contains the information distributed by the card index service for a full calendar year. The price of the 1960 volume is $75 postpaid, from The Engineering Index, Inc., 345 E. 47 St., New York 17, N. Y.

SOVIET RESEARCH ON GRAVITATION, by M. A. Garbill. This volume is an extensive summary of work done by Soviet scientists in the field of gravitation. It includes translations into English of Soviet articles, a correlation of Soviet and Western research, and a bibliography of both Soviet and Western publications on the subject. The book is available from the Gravity Research Foundation, New Boston, N. H., and is priced at $5.

MAGNETRONS, by Dr. K. Hinkel. Written for electrical engineers who must design or work with magnetrons, this text provides an extremely thorough analysis of the magnetron and test circuits, complete with graphs and formulas. The 104-page book also provides valuable information to engineers in the field of microwaves. Priced at $3.25, the hard-covered book is available from John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y.

DATA PROCESSING EQUIPMENT ENCYCLOPEDIA. This new 2-volume encyclopedia summarizes more than 300 different data processing machines, including more than 100 electronic computers. Volume I contains detailed specifications of electromechanical equipment. Volume II contains standardized entries for 107 digital electronic computers, seven MICR systems, and five optical scanners. Priced at $50, the encyclopedia is available from American Data Processing, Inc., 22nd Floor Book Tower, Detroit 26, Mich.

OTS REPORTS. On a variety of subjects, the following publications have been made available to the public by the Office of Technical Services. *Radiometry,* by V. I. Baranov, is a Soviet study translated into English of radioactivity basic concepts and methods of measuring radioactive irradiation, including procedures for radiometric analysis of rock specimens. Order no. AEC-tr-4432, 381 pages, $4.50. *Electric Powered and Solar Powered Food Warming Units for Space Vehicles,* by M. H. Rochman, et al. An Air Force study of electrical heating and direct thermal energy methods for warming food aboard a space vehicle resulted in the development of a solar-powered as well as an electric-powered food warmer. Order no. PB 171 605, 51 pages, $1.75. *Methods for the Control of Satellites and Space Vehicles,* R. E. Robertson (editor). A review of sensing and actuating methods for controlling satellites and space vehicles, with emphasis on systems exhibiting the most potential, is contained in this Air Force report on orienting man in space. Order no. PB 171 496, 443 pages, $6. *Cooling Large Electronics Packages,* by J. G. Moorhead. The size limits of electronics packages cooled by thermal conduction can be extended by using auxiliary thermoelectric refrigerator units in the package walls, according to an Army research study. Order no. PB 171 540, 40 pages, $1. *Measurement of Range and Intensity of Cyclotron Beams,* by J. R. Grover, et al. An accurate, reliable device to measure energy of the particles in an external cyclotron beam has been constructed for the Atomic Energy Commission. The device is simple to set up and operate, and uses a Faraday cup, a foil wheel, and a target holder. Order no. BNL 654-T-211, 5 pages, 50¢ *A Homing Parachute System,* by M. T. Kane, et al. An electro-mechanically controlled "homing" parachute potentially useful in missile nose cone recovery and air-dropping supplies has been developed for the AEC. Order no. SC-4537(RR), 35 pages, $1. *A Study of the Effect of Electron Beam Melting on Compounds and Metals,* by R. L. Martin, et al. The interstitial and sulfur contents of cobalt can be reduced by electron beam melting, and ductile cobalt sheet can be obtained from cobalt ingots by this method, according to the Air Force study. Order no. AD 248 588, 89 pages, $2.25 *Radioisotopes in World Industry—Abstracts of Selected Foreign Literature.* Radioisotopes in foreign industries are reviewed in a bibliography of 658 abstracts culled from foreign publications issued during 1959 and 1960, mostly in languages other than English. Order no. TID-6613, 141 pages, $2.50. *Selected Reactors of the Power Reactor Demonstration Program,* by J. S. Jacobs. This listing gives information on 11 power reactor projects under construction or planned. Order no. TID-3556 (Rev. 1), 51 pages, $1.25. Order from OTS, Washington 25, D. C.

RUSSIAN TRANSLATIONS

GENERAL INFORMATION

Starting with this issue, translated Tables of Contents and reviews of articles in the translated issues of the following Russian journals will appear in this newly created section of *Electrical Engineering*.

Radio Engineering
Radio Engineering and Electronic Physics
Telecommunications

The translated Tables of Contents will be taken from the Russian journal issues in process at Royer and Roger, the translator-publisher under contract to AIEE. The reviews will be prepared by three special review committees organized by the Communication Division, AIEE sponsors of this service.

The three Communication Division review committees were selected by C. E. Dean, vice-president Communication Division and L. G. Abraham, chairman Communication Division. The chairmen of these committees are:

R. D. Campbell	Radio Engineering
L. S. Schwartz	Radio Engineering and Electronic Physics
H. F. May	Telecommunications

The membership of the committees is made up of practicing engineers experienced in their respective fields.

See September issue of the bimonthly *Communication and Electronics* for a listing of the individuals making up the membership of these committees.

Royer and Roger editors of the three translated journals and their affiliations are as follows:

(РАДИОТЕХНИКА)

Radio Engineering:
IVO HERZER, Electronics Research Laboratories, Columbia University

(РАДИОТЕХНИКА И ЭЛЕКТРОНИКА)

Radio Engineering and Electronic Physics:
HERBERT DERN, Electronic Research Laboratories, Columbia University

(ЭЛЕКТРОСВЯЗЬ)

Telecommunications:
JACK WARREN, Hudson Laboratories, Columbia University

On page 36A of the September issue of *Electrical Engineering* will be found an advertisement describing the Translation Service with a tear-out return postcard. If individuals or groups are interested in subscribing to one or more of the translated Russian journals, the postcard should be returned promptly.

TRANSLATED TABLES OF CONTENTS

RADIO ENGINEERING, Vol. 16, No. 6, June, 1961

TABLE OF CONTENTS:

1. *Yevtyanov, S. I., and M. V. Kapranov,* Processes in High-Order Frequency Multipliers.
2. *Cherne, Kh. I.,* The Response of a Low-Frequency Filter With Trapezoidal Frequency Characteristic and Linear Phase Characteristic to Certain Signals.
3. *Fialko, Ye. I.,* Positive and Random Detection of Unstable Meteor Tracks.
4. *Perel'muter, S. S.,* Ferrite Valves with Decreased Dimensions and Weight.
5. *Fel'dshteyn, A. L.,* Methods for Solving Summation Equations.
6. *Viter, V. V., and K. V. Kul'kov,* Measuring the Coefficient of Automatic Correlation of a Random Signal Above the Threshold Level by Means of Pulse Counters.
7. *Voyshvillo, G. V., and N. D. Poroshin,* On the Theory of the Parametric Amplifier.
8. *Korneyev, L. A.,* The Influence of Lead Inductances of Tubes on the Work of a Quartz Oscillator.
9. *L'vovich, A. A.,* Device for Stabilizing the Amplitude of High-Frequency Voltage.
10. Gorokhov, P. K., History of Modern Television.

RADIO ENGINEERING AND ELECTRONIC PHYSICS, Vol. VI, No. 6, June, 1961

TABLE OF CONTENTS:

1. *Armand, N. A., et al.,* Long-Range Tropospheric Propagation of Ultrashort Radio Waves (survey).
2. *Khaskind, M. D.,* Propagation of Electromagnetic Waves Above a Gyrotropic Medium.
3. *Burevich, A. N.,* Asynchronous Oscillations in an Auto-Oscillator With 2 Degrees of Freedom.
4. *Kinber, B. Ye.,* Decoupling Between Nearby Reflector Antennas.
5. *Khokhlov, R. V.,* Theory of Radio Shock Waves in Nonlinear Transmission Lines.
6. *Benenson, L. S.,* Induced Vibrator Impedances in a Waveguide.
7. *Kasatkin, L. V.,* Measurement of the Radial Admittance of Axially Symmetric Structures With Inductive Walls.
8. *Barmenkov, O. A., et al.,* Theoretical and Experimental Studies of Klystron Frequency Dividers With Preliminary Bunching.
9. *Kanavrts, V. I.,* Oscillations in the Electron Flow at the Output of a Traveling-Wave Tube.
10. *Igrotskiy, A. L.,* Focusing the Electron Beam in a Traveling-Wave Tube by a Periodic Electrostatic Field.
11. *Bakhrakh, L. E.,* Geometric Parameters of Electron Beams in Ionic Focusing.
12. *Gurevich, S. B.,* Changing the Signal/Noise Ratio Due to Camera Tubes in a Television System.
13. *Breytman, V. M., et al.,* Mathematical Formulation of Problems in Corpuscular Optics With the Space Charge Taken into Account.
14. *Shveykin, Vi. I.,* Pulse Method of Determining the Parameters of Drift Triodes.
15. *Gorn, L. S., et al.,* Converting a Current Pulse from a Photoelectron Multiplier into a Voltage Pulse by Means of an Emitter Multiplier.
16. *Mel'nikov, B. S.,* Electronic Control of the Pulse Duration in an L-Oscillator Containing a Plane Semiconductor Triode.
17. *Basiv, N. G., et. al.,* Study of the Dependence of the Frequency of Molecular Beam Masers on Different Parameters. Part II—The J-3, K-3 Line.
18. *Karlov, N. V.,* Study of Delay Systems.

LETTERS TO THE EDITOR:

19. *Malyshev, V. A.,* Review of Articles on "The Theory of the Magnetron Oscillator."

CURRENT EVENTS:

20. *Vikhlyayeva, R. P., et al.,* The Interinstitutional Seminar on Cathode Electronics (18th meeting).

TELECOMMUNICATIONS, Vol. 15, No. 5, May, 1961

TABLE OF CONTENTS:

A message from the Central Committee of the Communist Party of the Soviet Union, the Presidium of the Supreme Soviet of the USSR and the Government of the Soviet Union.

1. *Zheleznov, N. A.,* Time Correlation Interval of Signals and its Relation to the Parameters of the Power Spectrum.
2. *Smirnov, V. A.,* New Methods for the Estimation of the Distortion at Multipath Signal Propagation.
3. *Nemirovskiy, A. S.,* Transmission Bandwidth for Signal and Distributed Reception of Signals at Ultrashort-Wave Tropospheric Propagation.
4. *Timichenko, U. G., and A. P. Arapenkov,* The Theory of Selective RC Amplifiers Using Semiconductor Triodes.
5. *Zarkhi, L. D.,* Investigation and Analysis of an Oscillator Using a Junction Semiconductor Triode in Unsaturated State.
6. *Ivanova, O. N., Kokhanova, Z. C., and A. P.*

Tsygankin, Programmed Operation of Automatic Telephone Offices.
7. *Chernenko, A. P.*, Inversion Effect of a Group of Telephone Channels on Nonlinear Noise Power.
8. *Vatsenko, V. A., and M. V. Gitlits*, Determination of Nonuniform Response of Ferromagnetic Carriers in Facsimile Reception.
9. *Arkhangelskiy, G. A.*, Effect of nonsymmetrical Load in H-F Cable Network.
10. *Glebovich, G. V.*, Transient Response of Coaxial Cables.

REVIEWS OF TRANSLATED ARTICLES

The following reviews cover articles in the first two 1961 issues of *Radio Engineering*. Starting in the November *Electrical Engineering*, reviews covering all three Russian journals will appear in this section.

Radio Engineering Vol. 16, No. 1 January 1961

Transmission of Signals by Pulse—Parameter Comparison Method. *N. T. Petrovich* (pp. 1-9)

Signal transmission to effect new types of communication based on comparison of parameters of successive pulses is discussed. By storing an nth pulse in a memory, delay line, tape, etc., the succeeding $(n+1)$th pulse is compared for changes in parameter which might be frequency, amplitude, or phase. Thus, any of the common forms of pulse communication can be analyzed. Application to relative phase telegraphy (RPT) is examined in detail, with particular emphasis on noise analysis.—R. S. Caruthers

Grooves and Strips with Rectangular Extension. *A. Ya. Yaskhin, N. N. Borison* (pp. 9-15)

This article analyzes the use of rectangular metallic extensions on strips and grooves to support H-waves rather than the TEM waves usually propagated by these printed-circuit equivalents to waveguides. Use of the metallic extensions rather than dielectric sheets greatly reduces losses. The fields external to the system are much weaker than with the TEM mode, thus reducing coupling problems.

Equations for the fields are developed by matching the boundaries at the rectangular extensions. Mode number and the characteristic propagation number k are derived in terms of the critical strip, groove, and extension dimensions. Curves are presented that show the relative independence of the wave number on the size of the gap and the more significant dependence on the width of the metallic extension.—Victor S. Carson

Transmission of Pulses Through a Comb Filter. *M. I. Finkel'shteyn* (pp. 23-30)

This paper deals with the transmission of N coherent pulses of rectangular shape through a comb filter.

For optimum processing of such pulses, before detection, a comb filter is required for which the frequency response matches the spectral density curve of the transmitted pulse. Such a filter is very difficult to construct and causes distortion of the pulse shape, changing the pulses from square to triangular with double base duration.

A multiple-tuned comb filter is suggested, having identical "teeth" with the frequency response of simple oscillatory circuits. The pass band $\Delta\omega$ of the teeth is given by $\Delta\omega = 2.48/NT$, where there are N pulses in the train each of duration T. In this case the signal-to-noise ratio is within 10 per cent of that obtained by an ideal storage device. Expressions for the transient response of such a filter are developed in terms of the number of side teeth in the filter. Experimental confirmation has been obtained.

The envelope of a pulse train at the filter output is derived on the basis of 90 per cent utilization of the signal energy.

Expressions are developed which permit the amplitude characteristic to be determined during the Mth pulse and succeeding interval. A numerical example is given to illustrate the use and method of applying the envelope equations to practical filters. Differences between the behavior of ideal storage devices (as used for comb filters) and the proposed arrangement are discussed. The width of the leading edge of the first pulse at the filter output is given by $0.25nF$ where there are inside teeth in the filter, and F is the repetition frequency. For a continuous filter for which the bandwidth encompasses that of the comb filter, the pulse amplitude will reach the 95 per cent line in a time t such that $t = 0.478/nF$. From these realizations it is deduced that the width of the leading edge of the first pulse is approximately one-half that of the last pulse in the train.—C. A. Parry

Recording Density of Wide-Band Signals. *I. Ye. Goron, Yu. P. Drobyshev* (pp. 53-61)

This is concerned with the various factors involved in judging the effectiveness and efficiency of magnetic tape recording of wide-band signals as required for television. Surface density, i.e., amount of information per unit area of the tape or signal carrier is introduced as an important criterion and stated to be novel.

Four different systems of signal division are considered, namely, the RCA color television, the VERA (BBC), the Bing Crosby, and Ampex systems. Besides the density of recording, various other considerations are included such as constructional difficulties, speed of tape, and potential maximum frequency. There is no conclusion that any one system has all the virtues.

There are seven references from Russian and U. S. sources, the most recent of which was published in 1957.—H. A. Affel

Radio Engineering Vol. 16, No. 2 February 1961

Impedance Matching in the Microwave Range by Means of Nonuniform Lines. *S. I. Orlov* (pp. 20-29)

The author develops a method by which a transformer in the form of an outside straight and inside tapered cylinder can be calculated, whose modulus of reflection coefficient matches an arbitrary impedance at a series of discrete frequencies within a given frequency range.

Starting from the Riccati equation which defines the reflection coefficient of a lossless uniform line, the author obtains through the assumption that the reflection modulus remains throughout the transformer in the vicinity of zero, a Fredholm integral equation of the first degree. Through Fourier series expansion, this leads to a system of linear equations whose results yield the function of integral reflections. The matching impedance is then obtained through integration of the internal reflections function. An example of calculation according to the developed theory is then presented, and obtained results compared with experimental data. Good agreement is obtained.

The paper seems to supply an interesting step toward the widening of the range of frequencies on which the loads and elements of the section match the characteristic impedance of the transmission line. The method to hold deviations within a given range, through lengthening the transformer, might also prove to be of further interest.—V. J. Nexon

Study of Linear Systems on the Basis of Fourier Analysis. *A. M. Zayezdniy* (pp. 33-45)

This is a tutorial paper explaining and illustrating a method of solving inhomogenous differential equations having constant coefficients and a driving function that is expressible as an infinite Fourier series. Such equations characterize response of linear electrical circuits to voltages such as square waves, saw-tooth waves, rectangular pulses, and other complex periodic voltages.

The key to successful solution by the author's method is the expressibility of such series in closed form which then permits successive differentiation of the series. Fourier series are not generally differentiable term by term, because of the frequent resulting nonconvergence.

The author shows that only five formulas are needed to obtain these closed forms for linear systems with constant

parameters exposed to an effect consisting of a linear combination of functions of $t^a e^{pt}$. Such systems and effects are typical of linear electric networks.

Examples are worked out using *RL*, *RC*, and *RLC* series circuits driven by the above-mentioned waveforms. The approach is essentially conventional in the use of the polynomial operator characteristic of linear differential equations. For the reader's benefit, it should be explained that the author uses the term "elementary fractions" for what are usually called "partial fractions." The exposition is good; the step-by-step development logical and understandable.—V. S. Carson

Impulse-Noise Limiter with Variable Threshold. A. A. Gorbachev (pp. 61-72)

An impulse-noise limiter in the low-frequency section of a radio receiver with a threshold which varies with the level of the received effective signal, shows experimental promise of more effectively reducing noise than a limiter with a fixed threshold determined by maximum signal level. The impulse-noise energy in the output of a limiter with variable threshold is less than the noise energy of a limiter with constant limiting threshold under the same receiving conditions. This article discusses the principal operating characteristics of this device.

The stability of the system and the effect of nonlinearity of the stage controlling the limiting level on limiter operation as well as nonlinear distortion of the signals in the limiter, are discussed.

Application of the variable threshold limiter in a broadcast receiver resulted in a substantial reduction in both atmospheric and industrial noise. However, efficiency of the limiter improved considerably when used in conjunction with signal and noise converters.—R. B. Meader

Pulse Generator with a Repetition Frequency Directly Proportional to Control Voltage. L. Ya. Il'nitskiy, V. V. Chervetsov (pp. 72-75)

This article describes a pulse generator having a repetition frequency directly proportional to a control voltage. A condenser C_1 connected across the grid of a cathode follower is linearly charged via a resistor R_1 and a diode connected to the anode battery E. A negative control voltage U_1 is also applied to the condenser via a second diode. When the charging voltage across the condenser becomes equal to the control voltage the charging is interrupted by the second diode, and the subsequent circuitry produces a sharp pulse of duration T_u to activate an electronic switch which discharges the condenser. The pulse repetition frequency is then

$$T = U_1 (R_1 C_1 / E) + T_u$$

The charging of C_1 is linearized by high negative feedback from the output of the cathode follower where, upon interruption of the charging, a sharp break occurs which is differentiated and then amplified to trigger a 1-shot multivibrator through a second cathode follower. The positive output pulse from the multivibrator then fires, through a second differentiating circuit, a normally open cutoff tube to discharge the capacitor C_1, whereupon the cycle repeats. The two differentiating circuits serve to shorten the trigger pulses.

The graph of Fig. 4 indicates a linear relationship over a repetition rate range $T = 10$ to 30 msec with control voltage U_1 range of 30 to 100 volts. The circuit employs two diodes, five triodes, and a pentode, double tubes being used where feasible. Four illustrations, one a schematic diagram, are included.—J. R. Hyneman

Adjustable Filter for Low-Frequency Microwave Range. A. M. Gasanov (pp. 80-83)

This paper discusses the practical configuration of a simple filter based on a strip transmission line, in the form of a conductor between two equipotential "sheets."

The diameter of the inner conductor is identical throughout the length of the filter. A stepped construction in the side plates permits the spacing between conductor and sheets to be varied and so attain different characteristic impedances of individual sections of the filter. The stepped construction is varied linearly in the plane perpendicular to the inner conductor. The behavior of the filter is likened to that of an "open" coaxial line. Thus the main energy is concentrated near the inner conductor, and the line properties are then determined by its configuration and the geometric dimensions in a small region in its immediate vicinity. The cutoff frequency is therefore determined by the relative lengths of the capacitive and inductive segments of the filter pertaining to the position of the central conductor.

Since the stepped construction is tapered, these segments will vary, depending on the relative position of the rod, and the cutoff frequency will vary accordingly. Since the basic line dimensions do not change, this variation is achieved without affecting the characteristic impedance of the filter. The tapered construction means that as the central conductor is shifted, the ends will tend to protrude. To overcome this mechanical problem the side plates can be extended perpendicularly to the conductor and designed to match the characteristic impedance of the filter. Curves for a 3-section test filter are given; they show a cutoff range of approximately 1.7 with an attenuation slope on the order of 60 db per octave.—C. A. Parry

MINIATURE SEARCH COIL

Greatly enlarged illustration of a miniature search coil developed at Battelle Memorial Institute shows size comparison of coil with edge of a 1-cent coin. Using the coil, scientists can measure eddy and induction currents to pinpoint physical defects and property variations in small and inaccessible parts. The loop of induction coil at the end of the probe consists of 200 turns of insulated wire about one third the diameter of a human hair. The wire, 0.00065 inch in diameter, is wound around an iron core that is 0.0008 inch in diameter. The coil is used in surveying and inspecting metal parts, such as extremely small electronic components and mechanical gears.

AIEE ON THE MOVE

56 Technical Sessions Arranged Tentatively for 1961 Fall General Meeting

A tentative technical program comprising 56 sessions has been announced for the AIEE Fall General Meeting, scheduled for October 15-20 at the Statler-Hilton Hotel in Detroit, Mich.

G. W. Romney, president of the American Motors Corporation, will be the featured speaker at the General Session which will be held Monday, October 16, at 2:00 p.m. Other events of the General Session will be an address by AIEE Pres. W. H. Chase and the appearance of Mayor L. C. Mariani of the City of Detroit, who will extend a welcome to the city.

Seven of the technical sessions will compose the 2nd Annual Symposium on Switching Circuit Theory and Logical Design, sponsored by the Computing Devices Committee.

All members are advised that due to exercise Sky Shield II, all commercial flights will be suspended from 1:00 P.M. Eastern Daylight Time, October 14 until 1:00 A.M., Eastern Daylight Time, October 15.

MONDAY, OCTOBER 16
9:00 A.M. SESSIONS

Data Communication

CP.* Simple Data Transmission Terminals.
J. M. Wier, Bell Tel. Labs.

CP.* A Multi-Frequency Data Set for Parallel Transmission Up to 20 Characters Per Second.
B. R. Saltzberg, R. Sokoler, Bell Tel. Labs.

CP.* An FM Data Set for Serial Transmission Up to 1600 Bits Per Second.
S. T. Meyers, Bell Tel. Labs.

CP.* PM Data Sets for Serial Transmission at 2000 and 2400 Bits Per Second.
P. A. Baker, Bell Tel. Labs.

CP.* An AM Vestigial Sideband Data Set Using Synchronous Detection for Serial Transmission Up to 3000 Bits Per Second.
F. K. Becker, J. R. Davey, B. R. Saltzberg, Bell Tel. Labs.

61-1063. A 1650-Bit Per Second Data System for Use Over the Switched Telephone Network.
S. Brand (deceased), formerly with Bell Tel. Labs. and Lockheed Electronics Corp.; *C. W. Carter* (retired), formerly with Bell Tel. Labs. (Re-presented for Discussion only)

61-1020. A Buffer Store for Data Transmission.
W. E. Baker, F. E. Froehlich, Bell Tel. Labs. (Re-presented for Discussion only)

Industrial & Commercial Power Systems

CP.* Problems in Electric Service for a Large Cement Mill.
R. F. Bergum, Detroit Edison Co.; *J. A. Allan*, St. Lawrence Cement Co.

CP.* Characteristics of Loads in a Cement Plant.
R. W. Sittner, General Elec. Co.

61-1033. Proposed New Breaker Ratings and Their Effect on Application for Industrial Systems.
A. H. Knable, Allis-Chalmers Mfg. Co.

CP61-1047. How to Select Overcurrent Relay Characteristics.
D. V. Fawcett, Canadian Westinghouse Co.

Transmission & Distribution

CP61-1062. Bibliography on Wood Pole Transmission Lines.
M. Darveniza, W. Wager, Univ. of Queensland

61-1043. Surge Impedance and Its Application to the Lightning Stroke.
C. F. Wagner, A. R. Hileman, Westinghouse Elec. Corp.

61-1036. Use of the A-C Network Analyzer and Electronic Differential Analyzer in the Study of Load-Frequency Control.
G. G. Richardson, Bonneville Power Admin.; *T. C. Wang*, Ill. Inst. of Technology

61-1027. Radio Influence Testing on 70 Miles of 345 KV Horizontal Bundle Conductor.
R. E. Graham, C. R. Bond, Ohio Edison Co.

61-1037. Pressure Type Connectors for Aluminum and Copper Conductors.
N. Shackman, R. W. Thomas, I-T-E Circuit Breaker Co.

Power System Communications

61-1011. Proposed Standard for Power System Communications Apparatus. AIEE Equipment Design Standards Sub. #6 of Power System Communication Com.
R. V. Rector, chairman

61-1010. Report of Methods of Measurements for the Application of Power Line Carrier. AIEE Methods of Measurements Sub. of the Power System Communications Com.
E. S. Kocsan, chairman

61-1050. Coded Feedback Communication Systems.
J. J. Metzner, K. C. Morgan, NYU Research Division (Re-presented for Discussion)

61-1096. Modulation and Signal Selection for Digital Data Systems.
R. M. Lerner, MIT (Re-presented for Discussion only)

61-1097. Binary Codes for Error Control.
W. W. Peterson, Univ. of Fla. (Re-presented for Discussion only)

Radio Communication Systems

61-1112. Digital Tropospheric Scatter.
J. R. Poppe, A. J. Vadasz, General Elec. Co.

61-1113. Santa Barbara County 6000 MC Microwave System.
R. K. Lentz, General Tel. Co.

CP.* Concentric Ring Antenna Array.
J. D. Tillman, G. W. Hoffman, Univ. of Tenn.

CP61-1114. Radar Tracking Accuracy Improvement by Means of Pulse to Pulse Frequency Modulation.
W. P. Birkemeier, Univ. of Wis., *N. D. Wallace*, Emerson Elec. Co.

CP61-1115. Active Doppler Acquisition Systems.

Ford Motor Company's Rouge Plant with the famous Ford Rotunda in the foreground is shown in this aerial view. The 2-square-mile industrial area includes blast furnaces, steel mill, foundries, pressed steel operations engine producing facilities, final assembly, and other operations. The Ford Rouge Plant will be offered as an inspection trip during the Fall General Meeting

CP.* A Static Approach to the Continuous Power Problem.
W. D. Modern, J. A. Laukaitis, J. L. Fink, General Elec. Co.

CP.* Carrier Checkback Schemes for Unattended Substations.
E. F. Statler, R. M. Reesey, Pa. Elec. Co.

Adaptive Communications

CP.* Adaptive Communication Systems.
G. S. Glinski, Univ. of Ottawa

CP.* Adaptive Digital Communication for a Slowly Varying Channel.
G. Lieberman, Radio Corp. of Amer.

CP.* A Variable Rate Binary Communication System.
N. G. Davies, W. L. Hatton, Canadian Defence Research Telecommunications Establishment

CP.* An Adaptive Communication System.
C. V. Jakowatz, General Elec. Research Lab.

*Conference papers will not be reprinted by the Institute; however, they may be available at the meeting at the discretion of the author.

C. H. Dawson, Philco Corp.

61-1048. A New Method of Space Exploration by Radar Using Incoherent Scattering.
T. Laaspere, Cornell Univ.

2:00 P.M. GENERAL SESSION

TUESDAY, OCTOBER 17
9:00 A.M. SESSIONS

Radiation Effects on Materials

CP.* Electrical Characteristics of Motional Pickup Transducers Under Combined Neutron and Gamma Irradiation.
P. S. Olson, C. G. Collins, General Elec. Co.

CP.* Mapping of the Gamma Radiation Field of the General Engineering Laboratory 1 MEV Linear Accelerator by Use of Bausch and Lomb Silver Phosphate Glass Microdosimeter Rods.
J. R. Coss, R. D. Downing, General Elec. Co.

CP.* Radiation Effects in Thermoelectrics I. The Effects of Ionizing Radiation on Commercial Grade Bismuth Telluride.

J. W. Winslow, Jr., U. S. Naval Radiological Defense Lab.

Symposium on Effect of Electric Arc Furnace Operation on Power Systems

CP61-1111. Effects of a Large Copper Melting Arc Furnace on an Electric Utility System.
C. S. Crow, W. Saller, Public Service Elec. & Gas Co.; *F. D. Shaw*, American Smelting & Refining Co. (formerly with Central Research Labs.)

T & D Symposium—Line Electrical Features

CP61-1104. Basic Parameters in Determining the Insulation Requirements of Transmission Lines.
J. M. Clayton, Westinghouse Elec. Corp.

CP61-1099. Selection of Single and Bundle Conductors and Accessories for Acceptable Radio Noise Performance.
L. O. Barthold, J. Kaminski, J. J. LaForest, General Elec. Co.; *H. E. House*, Alcoa.

61-1019. Safe Clearances and Protection Against Shocks During Live Line Work.
A. Elek, J. W. Simpson, Hydro-Electric Power Commission of Ontario

CP.* Questionnaire—Increasing Voltage of Existing Transmission Lines.
R. H. Cumming, New England Power Service Co.

Present Status of Fuel Cell Developments and Applications

CP.* Fuel Cell Power.
J. L. Platner, Allis-Chalmers Mfg. Co.

CP.* Status of Development and Future Prospects for the Ion-Exchange Membrane Fuel Cell.
G. A. Phillips, General Elec. Co.

CP.* Hydrogen-Oxygen Fuel Cell.
D. M. Gage, Union Carbide Consumer Products Co.

CP61-1092. Fuel Cells and Utilities.
J. D. Flynn, Cincinnati Gas & Elec. Co.

Data Communication

CP.* Four Phase Data System Evaluation by Digital Computer Simulation.
M. A. Rappeport, Bell Tel. Labs.

61-1065. Two Measuring Techniques for the Investigation of Impulse Noise and Drop-Outs On Phone Lines.
J. Kelley, J. Mercurio, D. Willard, Mitre Corp.

CP.* Use of Orthonomial Functions for Encoding Against Non-Gaussian Noise Ambients.
L. A. DeRosa, International Communications Systems

CP61-1066. Transistorized 2 x 24 Channel Carrier Telegraph Equipment.
K. Takahashi, T. Kishigami, Nippon Tel. & Tel. Public Corp.; *T. Matsuzaki, K. Sakurai*, Nippon Elec. Co.

61-1023. Computer Simulation of the Use of Group Codes with Retransmission on a Gilbert Burst Channel.
W. R. Cowell, H. O. Burton, Bell Tel. Labs. (Re-presented for Discussion only)

61-1012. Data System Tests Using Simulated Transmission Impairments.
F. T. Andrews, Jr., Bell Tel. Labs. (Represented for Discussion only)

2:00 P.M. SESSIONS

Chemical Industry

Corrosion in Action—International Nickel Co. (Film). Followed by Panel Discussion.

T & D Symposium—Tower Structural Features

CP61-1108. High Strength Steels for Tower Designs.
S. A. Wilson, Bethlehem Steel Co.

CP.* Higher Strength Steels Provide Design Flexibility.
J. C. Pohlman, U. S. Steel Co.

CP61-1045. A Study of Use of Aluminum Guyed Towers for Extra High Voltage Transmission Systems.
L. H. J. Cook, B. Cooper, Int'l Power & Engg. Consultants Ltd.

CP61-1100. Guyed Mast High Voltage Transmission Structures.
H. B. White, Aluminum Co. of Canada

CP61-1105. Development of Structure and Anchor Designs for Guyed "V" Type Towers.
E. S. Zobel, Amer. Elec. Power Service Corp.

Magnetohydrodynamic Electric Generation

CP61-1091. The Direct Generation of Electric Power from a High-Velocity Gas Jet.
D. J. Harris, Univ. of Sheffield.

CP.* MHD Generation in a Central Station Power Plant.
T. R. Brogan, Avco-Everett Research Lab.

CP.* Development of an MHD Generator.
S. Way, Westinghouse Elec. Corp.

Basic Sciences

61-1051. Signal Flow Graph Theory for Linear Time Variable Systems.
E. B. Stear, A. R. Stubberud, Univ. of Calif.

61-1053. Automatic Plotting of Characteristic Curves and Analogue Solution of Algebraic Equations.
D. Mitrovic, Univ. of Belgrade

CP.* An Analytic Approach to Root Locus.
R. A. Walsh, Monsanto Chemical Co.

CP.* Subarea Determination of the Capacitance of a Square Coplanar Two-Plate Capacitor.
B. L. Weinberg, T. J. Higgins, Univ. of Wis.

CP61-1052. Tunnel Diode Static Inverter.
J. M. Marzolf, U. S. Naval Research Lab.

Data Communication and Telegraph Systems

61-1029. A New Billing and Collection System Using Teletypewriter Techniques.
E. W. Henches, N. Y. Tel. Co.

CP61-1080. Videograph Communications Equipment.
J. J. Stone, Jr., A. B. Dick Co.

CP.* Evaluation of Data Transmission and Coding on a Large Multiple Terminal Network.
L. L. Corbett, M. Gordon, T. S. Stafford, IBM

CP.* Recording and Visual Analysis of "Noise" Errors.
A. E. Johanson, Bell Tel. Labs.

CP.* Some Error Characteristics of a Data Communication System.
R. L. Townsend, Bell Tel. Labs.

CP.* Operation of a Large Multi-Point Network for Data.
J. G. Glenn, Jr., Amer. Tel. & Tel. Co.

WEDNESDAY, OCTOBER 18
9:00 A.M. SESSIONS

Power Station Control

61-1032. Control System Design for Generating Stations.
J. G. Noest, G. S. Storms, Consolidated Edison Co. of N. Y.

CP61-1107. Industrial Control Application in Steam Electric Generating Stations.
M. P. Smull, Southern Services

CP.* Procedure for Controlling Power Plant Elec. Systems.
R. May, Toledo Edison

CP.* Control Power Sources in Electric Generating Stations.
R. B. Miller, M. P. Roller, Iowa-Ill. Gas & Elec. Co.

T & D Symposium—Tower Foundations

CP61-1044. Installation of Machine Drilled Caisson Footings in Non-Cohesive Soils.
J. C. Engimann, W. J. Fern, Commonwealth Edison Co.

CP61-1095. Special Transmission Tower Foundations.
A. A. Ferlito, A. V. Price, Ebasco Services

CP.* New Types of Footings for Transmission Line Structures.
F. W. Farr, A. A. Osipovich, Bonneville Power Admin.

CP61-1083. The Anchorage of Transmission Tower Foundations.
M. Markowsky, N. J. McMurtrie, Hydro-Electric Power Commission of Ontario

System Operation and Study

CP61-1054. The Load Flow Problem—Its Formulation and Solution—Part I. *A. H. El-Abiad*. Purdue Univ.
M. Watson, G. W. Stagg, Amer. Elec. Power Service Corp.

61-1055. Hydro-Thermal Economic Scheduling: Part IV—A Continuous Procedure for Maximizing the Weighted Output of a Hydro-Electric Generating Station.
B. Bernholtz, L. J. Graham, Hydro-Electric Power Commission of Ontario

CP61-1056. Input and Output Techniques for an On-Line Digital Computer.
W. G. Beyer, W. B. Schultz, J. W. Hissey, Leeds & Northrup Co.

CP61-1103. Use and Availability of Outage Records in the Planning of System Generating Plant Additions.
H. A. Adler, Commonwealth Edison Co.; *E. H. Loane*, General Public Utilities Corp.

Substations Round Table
Semiconductor Rectifiers

61-1076. Definitions for Semiconductor Rectifier Components. AIEE Rectifier Device Group of the Semiconductor Rectifier Com., J. R. Thurell, chairman.

CP61-1075. Semiconductor Rectifier Overload Ratings.

A facility comprising 28 acres under one roof in a building approximately one-half mile long, the Detroit Plymouth Assembly Plant of the Chrysler Corporation represents the largest volume production plant in the automobile industry. An inspection trip of this automobile assembly plant is planned for the Fall General Meeting

J. S. Read, E. E. Von Zastrow, General Elec. Co.

CP61-1089. Proposed Test Standards for Semiconductor Rectifier Cells, Rectifier Diodes and Rectifier Stacks. AIEE Rectifier Device Test Group of the Semiconductor Rectifier Com., R. D. Lynch, chairman.

CP.* Commutation Voltage Transients in Polyphase Semiconductor Rectifier Circuits. *N. A. Forbes, R. C. Whigham,* Westinghouse Elec. Corp.

CP.* Design, Production and Quality Requirements of Silicon Rectifier Diodes for Automotive Applications. *R. D. Lynch, L. F. Jones,* Westinghouse Elec. Corp.

Communications Switching I

CP61-1039. Economics of Exchange Lines Concentrators. *J. R. Kershaw.* Mich. Bell Tel. Co.

CP61-1040. Traffic Considerations in the Use of Exchange Line Concentrators. *W. J. Blyth,* Mich. Bell Tel. Co.

CP61-1041. The New Line Concentrator 1A. *W. Whitney,* Bell Tel. Labs.

CP61-1093. Field Experience with a Wire Spring Crossbar Concentrator. *R. P. Ebisch,* General Tel. Co. of Pa.; *J. S. Belcher,* Leich Elec. Co.

61-817. The Relative Merits of Time Division Multiplex Versus Space Division as a Mode of Operation for Electronic Telephone Exchanges. *J. G. Pearce,* General Dynamics/Electronics (Re-presented for Discussion only)

Wire Communications

61-1069. A Tone Disabler for Bell System 1A Echo Suppressors. *L. F. Bugbee, Jr.,* Bell Tel. Labs.

61-1046. A Stitched Wiring Process for Miniaturized Communications Electronics. *J. M. Coffin, L. B. Johnson,* Lenkurt Elec. Co.

CP61-1070. The NX1 Exchange Trunk Carrier Systems. *T. G. Fellows, A. Curran,* Northern Elec. Co.

CP61-1071. The Application of Carrier Systems to Exchange Trunk Plant in Canada. *A. Curran, T. G. Fellows,* Northern Elec. Co.

CP61-1101. Deviation Equalizer for "N" Carrier Lines. *M. Aruck,* Bell Tel. Labs.

2:00 P.M. SESSIONS

T & D Symposium—Advanced Line Design

CP61-1102. Transmission Lines on Restricted Rights of Way. *A. H. Anderson, M. Markowsky,* Hydro-Electric Power Commission of Ontario

CP61-1106. Reconductoring Transmission Lines. *J. R. Steiner,* Cleveland Elec. Illuminating Co.

CP61-1090. Conductor Vibration—A Study of Field Experience. *C. B. Rawlins, K. R. Greathouse, R. E. Larson,* Alcoa

61-1026. The Importance of Fretting in Vibration Failures of Stranded Conductors. *W. G. Fricke, Jr., C. B. Rawlins,* Alcoa Research Labs.

System Planning and Economics

61-798. Improving Transient Stability by Use of Dynamic Braking—Part I. *W. H. Croft, R. H. Hartley,* Ariz. Public Service Co. (Re-presented for Discussion only)

CP61-1059. Improving Transient Stability by Use of Dynamic Braking—Part II. *W. H. Croft, R. H. Hartley,* Ariz. Public Service Co.

61-1025. Determination of an Optimized Generator Expansion Pattern. *R. J. Fitzpatrick, J. W. Gallagher,* Phila. Elec. Co.

CP61-1057. The Break-Even Cost of Peaking Capacity. *F. M. Heck, Jr., C. Morrison,* Potomac Edison Co.

61-1014. A Further Look At Cost of Losses. *C. J. Baldwin,* Westinghouse Elec. Corp.; *C. H. Hoffman, P. H. Jeynes,* Public Service Elec. & Gas Co.

Induction Machinery

61-1094. The Theory of the Induction Machine With Conducting Sleeve Rotor. *E. C. Guilford,* Univ. of Wash.

61-1013. The Polyphase Induction Motor with Solid Rotor Effects of Saturation and Finite Length. *G. Angst,* General Elec. Co.

61-1038. Generalized Temperature Standards for A-C Motors. *C. G. Veinott,* Reliance Elec. & Engg. Co.

CP61-1067. Analogue for Canned Motor Temperature Analysis. *G. W. Penney,* Carnegie Inst. of Technology. *C. I. Thomson,* Westinghouse Elec. Corp.

CP61-1030. Application of General Equations of Induced Voltage and Armature Reaction —Part I: Performance of an Induction Machine. *H. H. Hwang,* Essex College, Assumption Univ. of Windsor.

61-221. Transient Torques in 3-Phase Induction Motors During Switching Operations. *M. R. Chidambara, S. Ganapathy,* Indian Inst. of Science (Re-presented for Discussion only)

Computers

CP.* Production of Large and Variable Size Logic Block Diagrams on a High-Speed Digital Computer. *D. A. Aaronson, C. J. Kinnaman,* Bell Tel. Labs.

61-1060. Analog Simulation of Digital Computer Programs. *R. Saucedo,* Westinghouse Elec. Corp; *T. W. Sze,* Univ. of Pittsburgh

CP61-1087. Shaft Multiplication Precision Angle Encoder. *D. A. Brouillette,* Datex Corp.

Communications Switching II

CP61-1034. An Electronically-Controlled Crossbar Switching System. *R. W. S. Kinsey* (deceased), formerly with Associated Electrical Industries (Woolwich); *J. E. Flood,* Assoc. Electrical Industries (Woolwich)

CP61-1109. Traffic Handling Possibilities with a Progressive Marking, Self Pathfinding Solid-State Crosspoint Network. *J. Draayer, A. Wachowski,* Automatic Elec. Labs.

CP.* Experience with the Morris Electronic Switching System. *B. J. Yokelson, G. Haugk,* Bell Tel. Labs.

CP.* Transmission Circuits for a Time Separation Electronic Switching System. *H. S. Feder,* Bell Tel. Labs.

CP61-1042. Small Crossbar CDO's. *J. W. Gaiser,* North Elec. Co.

Wire Communications

CP61-1086. Experience and Results Observed with DDD Transmission Design in Interconnection with the DDD Network. *D. H. Potter,* General Tel. Co. of Calif.

CP.* A New Transmission Test Set for Exchange Type Trunks. *E. H. B. Bartelink,* Northeast Electronics Corp.

61-1072. The Level Tracer, An Instrument for Time Saving and Better Measurement in the Speech Band.

PREPRINT PRICES

50¢ to Members.
$1.00 to Nonmembers.

ALL MAIL ORDERS must be accompanied by remittance in full or coupons.

COUPON BOOKS in $10 denominations may be purchased.

NUMBERED PAPERS only are available.

SEND ORDER and remittance to:
AIEE Order Department
345 East 47th Street
New York 17, N. Y.

M. Niedereder, Siemens & Halske AG; *B. T. Sanders Jr.,* Sanders & Associates

CP.* An Accurate Voice Frequency Level Calibrating Set for Field Use. *W. I. Cochran,* Bell Tel. Labs.

CP.* A Stable 1000-Cycle Tone Generator. *J. J. Kokinda, P. J. Kaltenborn,* Bell. Tel. Labs.

Substations Round Table

THURSDAY, OCTOBER 19
9:00 A.M. SESSIONS

Feedback Control Systems

61-1081. Self-Adaptive Systems with Variable-Parameter PID Controller. *Y. Kaya, S. Yamamura,* Univ. of Tokyo

CP.* An Exact Analysis of Sampled-Data Systems with Finite Sampling Time. *G. W. Howard,* Sandia Corp.; *T. J. Higgins,* Univ. of Wis.

New Energy Sources for Electronics I

CP.* Calculation of the Steady-State Performance of a Solar Powered Vacuum Thermionic Generator. *D. L. Dresser, D. R. Zimmerman,* General Motors Corp.

61-1078. Electrical and Pressure Losses in a Magnetohydrodynamic Channel Due to End Current Loops. *G. W. Sutton, H. Hurwitz, Jr., H. Poritsky,* General Elec. Co.

CP.* Theoretical and Practical Aspects of Fuel Cells. *P. Elving, C. L. Rulfj,* Univ. of Mich.

CP.* The Utilization of Hydrocarbons in Fuel Cells. *Y. L. Sandler,* Westinghouse Research Labs.

Rotating Machinery

CP61-1022. Circuit Analysis of Single-Phase Induction Motor Theories. *R. E. Bedford,* Indian Inst. of Technology

61-1028. Stability Limits of Synchronous Motors During Power System Disturbances. *L. Hannakam,* Allgemeine Elektricitaetsgesellschaft; *C. Concordia,* General Elec. Co.

61-1068. Single Phase Two-Valued Capacitor Motor Relay Selection. *D. L. Trower,* (formerly with Univ. of Cincinnati); *C. Evert,* Univ. of Cincinnati

61-1024. Magnetic Field of a Rectangular Commutating Pole. *A. I. Dvoracek,* Reliance Elec. & Engg. Co.

CP61-1110. Formette Testing of Armature Coil Insulation for Large D-C Machines. *J. S. David, G. D. McClary,* General Elec. Co.

Plasma Physics, Superconductivity, and Space Hazards

CP.* Current Status of Fusion Research. *R. G. Mills,* Princeton Univ.

CP.* Recent Developments in Superconducting Power Devices. *R. McFee,* Syracuse Univ.

CP.* Radiation Hazards in Space. *T. Foelsche,* Nat'l Aeronautics & Space Admin.

T & D Symposium—Conductors

61-871. Bibliography on Bundled Conductors. *D. H. Sandell,* Alcoa; *A. N. Shealy,* Kaiser Aluminum & Chemical Corp.; *H. B. White,* Aluminum Co. of Canada

61-1035. A Review of NESC Wind Load Requirements with Relation to Conductor Diameter. *R. L. Retallack,* Amer. Elec. Power Service Corp.

CP61-1085. Tower Design Loadings and Broken Wire Assumptions. *N. J. McMurtrie,* Hydro-Electric Power Commission of Ontario

CP.* Field Testing of Tower for Broken Conductor Impact Load. *E. S. Zoble, J. W. Stefoff, R. L. Swart,* Amer. Elec. Power Service Corp.

Safety

CP.* Underwriters' Laboratories, Inc. Fact-Finding Investigation on Two vs. Three Running Overcurrent Units for the Protection of Three-Phase Motors. *R. H. Yerke,* Underwriters' Labs.

This glittering white marble and stainless steel 14-story structure of contemporary design, located adjacent to the Detroit Civic Center, is the Main Office of Michigan's largest bank, the National Bank of Detroit. An inspection trip to tour this building with its many unique electronic facilities has been arranged for the Fall General Meeting

Panel Discussion on "Electrical Safety in Swimming Pools"

Moderator: H. B. Whitaker, Underwriters' Labs.

CP.* The Problem as it Relates to the National Electrical Code.
H. H. Watson, General Elec. Co.

CP.* The Problem from the Point of View of the Manufacturers and Installers of Swimming Pools.
D. L. Doughty, Orinda Pools and National Swimming Inst.

CP.* The Lighting Problem.
W. P. Lowell, Jr., Sylvania Elec. Products

CP61-1088. Shock Hazard in Swimming Pools from Submerged 120 Volt Lighting.
W. P. Taylor, R. J. Arthur, Sr., Baltimore Gas & Elec. Co.

CP.* A Possible Solution.
L. S. Inskip, Bell Tel. Labs.

Transformers

61-1073. The Leakage Reactance of a Ring-Type Transformer.
P. P. Yeh, Eisler Transformer Co.

61-1074. Reactance and Kilowatt Losses of Multi-Circuit Transformers.
M. W. Waterman, Allis-Chalmers Mfg. Co.

2:00 P.M. SESSIONS
New Energy Sources for Electronics II

Transformers

CP.* Electrical Characteristics of Wire Enamels as Affected by Temperature and Various Environmental Conditions in Transformer Oil.
M. F. Beavers, G. F. Lipsey, General Elec. Co.

CP.* A New Transformer Insulation.
B. D. Brummet, F. S. Sadler, Thomas A. Edison Research Lab.—Division of McGraw-Edison Co.

Substations
Progress in Accelerators

CP.* Developments in High-Intensity Multi-Bev Accelerators.
A. V. Crewe, Argonne Nat'l Lab.

CP.* The New Generation of Medium Energy Cyclotrons.
K. R. MacKenzie, Univ. of Calif.

CP.* Development of High-Intensity Pion-Producing Accelerators.
J. A. Martin, Oak Ridge Nat'l Lab.

CP.* Developments in Ultra-High Energy Accelerators.
J. P. Blewett, Brookhaven Nat'l Lab.

Space Communication Systems

CP.* Application of Solid State Devices to Space Telemetry.
W. B. Allen, Hughes Aircraft Co.

CP.* The Planning of Commercial Satellite Communication Systems.
J. L. Glaser, Bell Tel. Labs.

CP.* Thermoelectric Cooling of Semiconductor Components.
R. Marlow, R. M. Carey, Texas Instruments.

Excitation Systems

61-1021. Retirement Problems in Generation Expansion Planning.
C. J. Baldwin, Westinghouse Electric Corp.; *C. H. Hoffman, P. H. Jeynes*, Public Service Elec. & Gas Co.

61-1015. Analogue Computer Production Testing of Electric Utility Voltage Regulators.
G. S. Chambers, L. J. Lane, A. S. Rubenstein, General Elec. Co.

61-1017. A Static Excitation System for Industrial and Utility Steam Turbine-Generators.
L. M. Domeratzky, A. S. Rubenstein, M. Temoshok, General Elec. Co. (Re-presented for Discussion only)

61-1018. Design and Tests of a Static Excitation System for Industrial and Utility Steam Turbine-Generators.
L. J. Lane, D. F. Rogers, P. A. Vance, General Elec. Co. (Re-presented for Discussion only)

Technical Committee Chairmen To Hold Forum

In connection with the Fall General Meeting, a Forum of Technical Committee Chairmen and others responsible for AIEE organizational matters will be held in Detroit, Mich., on Wednesday, October 18, at 7:30 p.m., in the Bagley Room, Statler Hilton Hotel.

Invitations to speak have been extended to AIEE President W. H. Chase, the honorary chairman; to P. K. McElroy, on the topic "ITGs (Institute Technical Groups) Come Closer into Focus," and to Dr. C. G. Veinott, on "AIEE's Place in Standardizing Activity."

FRIDAY, OCTOBER 20
9:00 A.M. SESSIONS

Second Symposium on Butyl Rubber Wire and Cable Insulations

CP.* Electrical Characteristics of Butyl Rubber Insulations at 125°C.
N. D. Kenney, T. N. Metropolus, W. L. Seamonds, Simplex Wire & Cable Co.

CP.* Continued Evaluation of Butyl Rubber Insulated Cables.
J. R. Maher, J. C. Carroll, General Elec. Co.

CP.* Some Aspects of the Dielectric Strength of Butyl Rubber Insulated Cables.
W. A. Beasley, Anaconda Wire & Cable Co.

CP.* Butyl Rubber Network Cables for 260° C Limiter Operation.
R. H. Carlson, Amer. Steel & Wire Co.

Industrial Control

61-1082. Shading Coil Magnet of New Design.
H. J. Kubiak, Univ. of Wis.; *L. H. Matthias*, Allen-Bradley Co.

61-650. Characteristics of A Synchronous Induction Motor.
A. E. Snowdon, E. W. Madsen, Superior Elec. Co.

CP61-1058. Design Development for Safer Press Controls.
E. F. Drake, Clark Controller Co.

CP.* The Roof Drive System for the Pittsburgh Public Auditorium.
A. J. Baeslack, J. G. Peterson, Jr., Westinghouse Elec.; *I. Braunstein, E. Cohen*, Ammann & Whitney

Power Generation

CP.* EHV System Overvoltages Following Load Rejection of Hydraulic Generators.
P. L. Dandeno, K. R. McClymont, Hydro-Electric Power Commission of Ontario

CP.* Analogue Computer Studies of System Overvoltages Following Load Rejections.
F. P. deMello, A. C. Dolbec, D. Swann, M. Temoshok, General Elec. Co.

61-1016. Recent Developments in Amplidyne Regulator Excitation Systems for Large Generators.
G. S. Chambers, A. S. Rubenstein, M. Temoshok, General Elec. Co.

2:00 P.M. SESSIONS

Second Symposium on Butyl Rubber Wire & Cable Insulation

CP.* Development of Butyl Rubber Insulated Airport Lighting Cables.
R. C. Graham, S. R. Lynch, Rome Cable Co.

CP.* Design and Manufacture of Butyl Rubber Insulated Dredge Cables.
P. Gibbon, J. Campbell, Northern Elec. Co.

CP61-1098. Survey on the Use of Butyl Rubber Insulated Cable.
L. D. Cronin, Ebasco Services; *R. E. Hoy*, Enjay Chemical Co.; *J. E. Johnson*, Phila. Elec. Co.

SYMPOSIUM PROGRAM GIVEN

Papers in the 2nd Annual Symposium on Switching Circuit Theory and Logical Design will be available as special publication S-134. The price will be $6.50 to all.

The tentative technical program for this symposium follows:

TUESDAY, OCTOBER 17
2:00 p.m. Computing Devices

Part I—Keynote Session

Welcome Address—R. S. Ledley, National Biomedical Research Foundation

Opening Remarks—T. H. Mott, Jr., Lockheed Electronics Co.
Invited Address—H. Aitken, Harvard Univ.

Part II—Minimization of Boolean Functions

CP.* An Application of Linear Programming to the Minimization of Boolean Functions.
A. Cobham, R. Fridshal, J. H. North, IBM

CP.* Minimal Sums for Boolean Functions Having Many Unspecified Fundamental Products.
E. J. McCluskey, Jr., Princeton Univ.

CP.* Use of a List Processing Language in Programming Simplification Procedures.
S. R. Petrick, Electronics Research Directorate

WEDNESDAY, OCTOBER 18

9:00 a.m. Threshold Logic Design

CP.* Threshold Logic and Two-Person Zero-Sum Games.
S. B. Akers, Jr., General Elec. Co.

CP.* On the Characterization of Threshold Functions.
C. K. Chow, Burroughs Corp.

CP.* Functional Forms of Majority Functions and a Necessary and Sufficient Condition for their Realizability.
S. Muroga, IBM Research Center

CP.* The Profile Technique for the Design of Threshold Device Logic.
O. B. Stram, Burroughs Corp.

CP.* More About Threshold Logic.
R. O. Winder, RCA Labs.

2:00 p.m. Neuron Physiology and Threshold Logics

CP.* The Integrative Properties of Neurons.
D. Kennedy, Stanford Univ.

CP.* Mathematical Models of Neurone Interaction.
H. D. Landahl, Univ. of Chicago

CP.* Multivalued Logic Devices for Simulating Threshold Neurons.
D. R. Boyle, R. S. Ledley, National Biomedical Research Foundation

CP.* Many Valued Logics and Reliable Homeostatic Processes.
J. D. Cowan, MIT

THURSDAY, OCTOBER 19

9:00 a.m. Introduction to Speed—Independent Circuits

CP.* An Introduction to Speed Independent Circuit Theory.
R. E. Miller, IBM Research Center

CP.* One Method for Designing Speed Independent Logic for a Control.
R. E. Swartwout, Univ. of Ill.

CP.* Problems in the Physical Realization of Speed Independent Circuits.
J. E. Robertson, Univ. of Ill.

CP.* A Flow Chart Notation for the Description of a Speed Independent Control.
D. B. Gillies, Univ. of Ill.

2:00 p.m. Samuel H. Caldwell Memorial Session: Finite Automata

CP.* S. H. Caldwell, 1904-1960.
E. J. McCluskey, Jr., Princeton Univ.

CP.* Transcient Behavior in Iterative Combinational Switching Network.
W. L. Kilmer, Montana State Coll.

CP.* Operations on Finite Automata.
C. C. Elgot, J. D. Rutledge, IBM Research Center

CP.* Delayed Logical Finite State Machines.
D. Arden, MIT

CP.* Techniques of the Diagnosis of Switching Circuit Failures.
J. M. Galey, R. E. Norby, J. P. Roth, IBM

8:30 p.m. Informal Evening Session: Open Problems in Switching Theory

FRIDAY, OCTOBER 20

9:00 a.m. Logic Network Synthesis

CP.* Canonical Forms of Functions in P-Valued Logics.
M. Cohn, Sperry Rand Research Center

CP.* Boolean 2-Terminal Synthesis Based on Incidence Matrices.
S. Okada, K. P. Rajappan, Stromberg Carlson Co.

CP.* A Computer Program for the Synthesis of Combinational Switching Circuits.
R. M. Karp, F. E. McFarlin, J. P. Roth, J. R. Wilts, IBM General Products Div.

CP.* Automatic Fault Detection in Combinational Switching Networks.
W. H. Kautz, Stanford Research Inst.

2:00 p.m. Proposed Graphical Symbols for Digital Computers

CP.* History of Logic Diagramming Standardization and Status Report on ASA-Y32.14—Graphical Symbols for Logic Diagrams.
T. H. Mott, Jr., Lockheed Electronics Co.

CP.* ASA-Y32.14 Proposals for an American Standard.
A. L. Reiche, Remington Rand UNIVAC

CP.* Report of Symbology Task Force of AIEE Computer Standards Subcommittee.
R. C. Boden, IBM

CP.* Report on a Symbols Usage and Preference Survey of the AIEE Computing Devices Committee.
R. M. Kalb, Remington Rand UNIVAC

CP.* A Readability Comparison of Two Proposed Logic Symbol Types in an Equipment-Oriented Problem Solving Environment.
J. D. Baker, A. J. Whitehurst, AFESD

CP.* A Study of Two Proposed Logic Symbol Systems for Recognition and Function-Association Characteristics.
G. W. Allen, IBM

Tentative Schedule of Events

Sunday, October 15
2:00 p.m.—Registration
4:00 p.m.—Welcome Tea

Monday, October 16
8:30 a.m. Trip to Ford Motor Rouge Plant
9:00 a.m. Ladies' Coffee Hour
2:00 p.m. General Session
Speaker: G. W. Romney

Tuesday, October 17
8:45 a.m. Trip to General Motors Technical Center
9:00 a.m. Ladies' Coffee Hour
1:30 p.m. Trip to Michigan Bell Telephone Data Processing Center
1:45 p.m. Ladies' Civic and Cultural Tour
6:00 p.m. 50th Anniversary Dinner-Dance

Wednesday, October 18
9:30 a.m. Trip to the National Bank of Detroit
9:30 a.m. Ladies' and Gentlemen's Tours and Luncheon at Greenfield Village
1:00 p.m. Trip to Enrico Fermi Atomic Power Plant
7:00 p.m. Trip to International Salt Co. Detroit Mine

Thursday, October 19
8:45 a.m. Trip to Chrysler Corp. Plymouth Plant
9:45 a.m. Ladies' Tour to Canada
1:15 p.m. Trip to Phoenix Memorial Laboratory, University of Michigan
1:30 p.m. Trip to Detroit General Post Office
8:00 p.m. Evening Party

Friday, October 20
No social events scheduled.

Nomination of AIEE Officers Begins for Election by Voters in Spring of 1962

For the nomination of officers to be voted upon in the Spring of 1962, the AIEE Nominating Committee will meet in New York, N.Y., January 29, 1962. The officers to be elected are: a President, a Treasurer, two Directors-at-Large, eight District Vice-Presidents, one from each of the odd-numbered geographical Districts, three Technical Vice-Presidents, and two Department Directors. Fellows only are eligible for the office of President; Members and Fellows for the offices of Vice-President, Director, and Treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for consideration of the committee, all suggestions must be received by the Secretary of the committee at the Institute headquarters, not later than December 15, 1961.

In accordance with the provisions in the Constitution and Bylaws, quoted in the following paragraphs, actions relating to the organization of the Nominating Committee are now under way:

CONSTITUTION

C60.010 Nominating Committee. The Nominating Committee is composed of voting members, as defined in C20.110, selected by and representing parts of the Institute as follows:

C60.011 Districts have one representative each.

C60.012 Technical Divisions have one representative each.

C60.013 Board of Directors has representatives not exceeding the number of Technical Divisions.

C60.014 Secretary. The Executive Secretary of the Institute acts as Secretary of the Nominating Committee, without vote.

C60.020. Nominations. The Nominating Committee meets and nominates candidates for Institute offices according to instructions contained in the Bylaws. The committee names one candidate for each vacancy in the office of President, Treasurer, and Directors-at-Large. It includes in its slate such candidates for (a) Vice-Presidents as have been nominated by the Executive Committees of the Districts concerned, (b) Vice-Presidents as have been nominated by the Technical Divisions concerned, and (c) Directors as have been nominated by the Departments concerned. If a District, Division, or Department fails to nominate a candidate for Vice-President or Director, the Nominating Committee nominates a candidate from the unit concerned. Additional nominations for any office may be made by written petition of 25 or more voting members, in accordance with the rules set forth in the Bylaws. For the office of District Vice-President, the petitioners must be from the Districts concerned.

C60.021. Candidates for any office must

hold a grade of membership which entitles them to serve if elected.

B60.011. District Members of Nominating Committee. Each District has one representative on the Nominating Committee. During September of each year, the Secretary of the Nominating Committee shall notify the Chairman and Secretary of the Executive Committee of each District that, by December 15 of that year, each district should select a representative to serve as a member of the AIEE Nominating Committee, and an alternate to serve if the representative is unable to attend the meeting of the Nominating Committee.

B60.012. Technical Division Members of Nominating Committee. During September of each year, the Secretary of the Nominating Committee shall notify the Chairman and Secretary of each Technical Division that, by December 15 of that year, each Technical Division should select a representative to serve as a member of the AIEE Nominating Committee, and an alternate to serve if the representative is unable to attend the meeting of the Nominating Committee.

B60.014. Secretary of Nominating Committee is as defined in C60.014.

B60.020. Procedure for Nominations. The Secretary of the Nominating Committee shall give the members not less than 10 days' notice of the first meeting of the Committee, which shall be held not later than February 15. At this meeting, the Committee shall elect a Chairman and shall proceed to make up a ticket of Nominees for the offices to be filled at the next election.

During September of each year, the Secretary of the Nominating Committee shall notify the following groups that nominations, as designated, should be received by the Secretary of the Nominating Committee by December 15th of that year:

a. The Chairman and Secretary of the Executive Committee of each District, in which there will be during the year a vacancy in the office of District Vice-President, a nomination for a District Vice-President, made by the District Executive Committee;

b. The Chairman and Secretary of each Technical Division, in which there will be during the year a vacancy in the office of Technical Vice-President, a nomination for a Technical Vice-President, made by the Technical Division Committee;

c. The Chairman and Secretary of each Department, in which there will be during the year a vacancy in the office of Department Director, a nomination for Department Director made by the Department.

B60.022. Independent Nominations. Additional nominations for any office may be made in accordance with C60.020. Petitions, proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with C60.020, shall be received by the Executive Secretary not later than March 15 of each year. These nominations shall be included on the ballot if such candidates are eligible.

B60.030. Ballots. On or before April 15 of each year, the Executive Secretary shall mail to all qualified voters an official ballot on which are to be listed all eligible candidates, nominated as provided in C60.020. The candidates of the Nominating Committee shall be appropriately designated as such. Any nominee may, prior to the printing of the ballots, withdraw his name by written request to the Executive Secretary, whereupon that fact shall be suitably indicated upon the ballot.

In the event of no contest for any office, the slate of the Nominating Committee, in the form of a ballot, and having a reference to the biographies of the candidates in *Electrical Engineering*, shall be mailed to the voting members.

B60.031. Methods for Balloting. The voting for each office shall be restricted to the nominees for that office as printed on the ballot. When there is a contest for any office, the ballot shall be accompanied by an envelope on which shall be printed the title of the Institute, the name and address of the Executive Secretary, and the words, "Official Voting Envelope—Enclosing a Ballot Only." The names of the nominees shall be written, printed, or otherwise marked on a single ticket or ballot, which shall be enclosed in a sealed unmarked, and unidentified inner envelope of any suitable character, which shall in turn be enclosed either in the "Official Voting Envelope" (received from the Executive Secretary), or any other envelope, marked on its face, "Non-Official Voting Envelope—Enclosing a Ballot Only." The outer envelope of either class shall be identified by the name of the sender, shall be sealed and, in order to be counted, shall reach the Executive Secretary not later than the first day of June.

B60.040. Tellers Committee Appointment. The President, during the month of May, shall appoint, subject to the approval of the Board of Directors, a Tellers Committee. This Committee shall be selected from voting members. Members of the Board of Directors, members of the Nominating Committee and their alternates, or any nominee appearing on the ballot, or petitioners of a nominee, are ineligible to act as tellers. Other appointees as tellers are authorized by written petition delivered to the Executive Secretary on or before the first day of May. A minimum of 20 signatures of voting members is required. A petitioner is eligible to sign only one petition. Each signer shall have the qualifications of a teller.

B60.041. Tellers Committee Report. The Tellers Committee shall meet at the office of the Institute as soon after the first day of June as possible and prepare an Election Report; one copy filed with the Executive Secretary, the other copy with the Chairman of the Tellers Committee and kept sealed until presented to the presiding officer of the ensuing Annual Meeting. In the absence of the Chairman of the Committee, the Executive Secretary will present his copy of the Election Report. The Tellers' Election Report shall give the sum total of the ballots received, and shall designate this total as a vote for the entire slate of officers where there are no alternative candidates. Only in the case of a contest shall an individual count be made. The presiding officer at the Annual Meeting shall cause the report to be read, and shall declare those duly elected in accordance with the results of the vote as presented in the report.

(Signed) N. S. Hibshman
Executive Secretary

Group Relationships Described among Local ITGs, Sections, and TDGs

In connection with the formation of Institute Technical Groups (ITGs), questions have been raised as to the relations between local Chapters of ITGs and the corresponding Sections and as to the effect of new ITGs on existing Technical Discussion Groups (TDGs).

Of course, the ITGs may have considerable autonomy when the members specifically desire it. However, it is expected that, in most cases, the relations will be as shown in the diagram on the next page.

From the left-hand side of the sketch, a local Chapter of an ITG will usually be part of the local Section. Money for local Chapter purposes will come to them through the local Section. In many cases, an ITG Chapter will be part of a local TDG, with the ITG Chapter giving the local TDG added strength. However, there will be a technical relationship directly between the ITG Chapter and the National ITG Committee, as indicated by the dashed lines, to stimulate the technical interests peculiar to that particular field. In cases where there are local ITG members in insufficient numbers to form a local Chapter, the members will belong to the local Section and often to a local TDG, but will receive technical information directly from the national ITG of their choice.

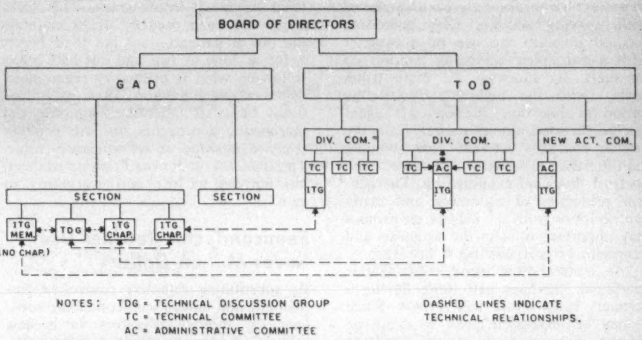
On the right-hand side of the sketch, it will be noted that national ITGs will usually be sponsored by Technical Committees (TCs) in Divisions. In certain cases, however, two TCs may sponsor one ITG by means of an Administrative

Committee. In addition, when a new technical subject without an existing TC justifies an ITG, the New Activities Committee may sponsor an ITG via an Administrative Committee.

The 200th application was received at Headquarters on August 15 for charter membership in the ITG on Automatic Control now being formed with the sponsorship of the Feedback Control Systems Committee, Industry Division, and with the backing of the Industrial Control Committee of the same Division. This is the first proposed ITG, of Headquarters record, to reach that status. Its scope and other pertinent information will be published when available in *Electrical Engineering*.

Applications from AIEE members for charter membership in this ITG may be addressed to the Manager of Technical Operations Services, AIEE, 345 East 47th Street, New York 17, N. Y. When the 300th applicant has so applied, bills based upon $4.00 annual dues will be sent out. After dues from 250 applicants have been received, the ITG on Automatic Control will become permanent. After that time, members of the ITG in any Section may petition the Section to recognize them as an ITG Chapter and to hold local meetings. Sections may assist and encourage this movement.

Inquiries, other than applications, may be addressed to the chairman of the Feedback Control Systems Committee, H. T. Marcy, Chairman, IBM Corporation, Box 390, Boardman Road, Poughkeepsie, N. Y.



Relations among the ITGs, TDGs, and ACs illustrated. Both the General Administration Department (GAD) and Technical Operations Department (TOD) are organized under the Board of Directors

Pacific Meeting Session Stresses Electrical Techniques in Cardiology

Engineers attending the Institute's Pacific General Meeting in Salt Lake City, Utah, in August, were presented with a varied program of great interest. One of the highlights of the meeting was a 2-paper session on electrical instruments in biology. The first paper in the session appears in this issue on page 761. The second will be discussed briefly in the following paragraphs.

Dr. Charles T. Dotter of the University of Oregon Medical School presented the second paper, "Electronics, Plumbing and Last-Chance Cardiology." He immediately gained the attention of his audience by stating that thus far medicine has had no effective means for enlarging narrowed, diseased coronary blood vessels even though half a million Americans died last year because of failure of the coronary arteries to supply the heart muscle with blood. He stated further that the most direct approach to the problem would appear to be an enlargement, replacement, or reaming of the diseased coronary arteries. An analogy to narrowing of a fuel line may be crude, Dr. Dotter said, but the therapeutic implications are identical—relief of the obstruction.

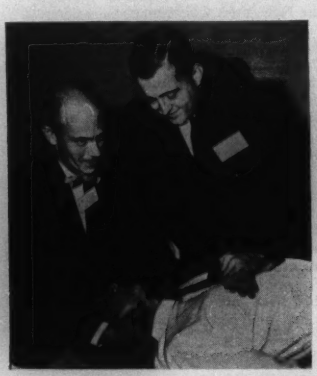
"Prior to a direct attack upon the diseased vessel, it must first be possible to find the narrowed areas," Dr. Dotter said. "To this effect, considerable investigative work has been expended in techniques for visualization of the coronary vessels by means of radiography, utilizing radiopaque fluids injected so as to fill the coronary arteries and thereby make them visible on X-ray films. A number of highly specialized approaches for directing the injection into the small but

Courtesy Utah Power Co.

President W. H. Chase (left) and F. O. Wald, Hotel and Facilities Chairman for the Pacific General Meeting with American Airlines' stewardess after Mr. Chase's early-morning arrival in Salt Lake City

Courtesy Salt Lake Tribune

President Chase and Pacific General Meeting Co-Chairman R. A. Radford, Director Bradley Cozzens, and Pacific General Meeting General Chairman H. E. Hodgins have an informal discussion



Courtesy Salt Lake Tribune

Dr. C. T. Dotter (left) and G. G. Knickerbocker demonstrate a method for keeping blood circulating through the body though the heart is dead. Both men presented papers at Salt Lake City

important coronaries have been employed with varying success. One promising method involves the use of a catheter with a concentric occluding balloon on its shaft. By blocking the main trunk aorta (with the balloon) during the period of injection, the contrast agent can be directed almost entirely into the branch coronary arteries, thus avoiding the otherwise inevitable washout of both contrast fluid and examination. The general principles of plumbing and many contributions from the field of electronics play important roles in the diagnosis and treatment of coronary heart disease."

"As matters now stand," Dr. Dotter continued, "perhaps half those having a coronary heart attack will recover. Since it may be impossible prior to death or definite recovery to know the outcome of a given heart attack, medical conservatism has understandably slowed our progress in this type of research. No doctor is likely to give up a 50-50 chance for his patient in exchange for a difficult operation or procedure of unproved value."

"This major hurdle can now be overcome," he stated. "The closed chest cardiac resuscitation technique described by Kouwenhoven, Jude, and Knickerbocker can be applied to heart attack patients at the moment of, or even a minute or two after, legal 'death' occurs from coronary insufficiency. This technique has been used by us to maintain the life of patients—but not their hearts—for as long as two and one-half hours following what is ordinarily regarded as death of the individual. Thus, an opportunity exists to undertake diagnostic and therapeutic approaches hitherto prohibitively dangerous or of unknown value. The patient, under such circumstances, has nothing to lose and everything to gain."

Semiconductor-Rectifier Use Saves Million Dollars

By substituting remotely controlled germanium and silicon semiconductor rectifiers for motor generators in a new refinery, Kennecott Copper Corp. estimates a million-dollar saving in electrical equipment. This fact was reported by D. T. Young of Kennecott at the Pacific General Meeting. He stated that each rectifier in the new Baltimore, Md., refinery is located adjacent to the electrolytic cell it serves rather than being centrally located.

Rectifiers controlled by induction voltage regulators operate at 90 per cent or higher power factor, eliminating the need for corrective equipment. Static-controlled regulators are generally more desirable, but their low power factor made them undesirable at the Baltimore refinery, Mr. Young said.

Electric Drive for Off-Highway Vehicles

An electric transmission to replace mechanical or hydraulic drives used normally for off-highway vehicles was described at the Pacific General Meeting.

T. T. Means, in presenting a paper by H. J. McLean and H. Vitt of General Electric Co., described the problem of translating engine horsepower into effective rim pull on all the wheels of a tractor-trailer vehicle as a natural application for electric drive with its inherent ability to locate the driving motors at the point of use. Authors McLean and Vitt described a heavy-duty traction motor drive designed so that four motors can deliver the full output of engines rating up to 1,600 hp for traction. The system provides 60 per cent adhesion on all wheels at standstill and full horsepower utilization over most of the speed range to a maximum of 35 mph.

Another method discussed was one which reduced operating expense by increasing the vehicle pay load. This is accomplished by placing the traction motor inside the rim of off-highway tires. The frame of the traction motor is used as the axle of the wheel.

Electrical Engineering Exposition To Occupy 2nd and 4th Floors of Coliseum

The 1962 Electrical Engineering Exposition that will be held in conjunction with the AIEE Winter General Meeting in New York has taken another step in its effort to integrate its exhibits with the scientific sessions.

The joint event—the first industry-wide Exposition sponsored by the AIEE—will be held January 29-February 2, 1962, in the New York Coliseum.

H. F. Grebe, exhibits manager of the Reber-Friel Company of Philadelphia, Pa., exposition management firm in charge of the Exposition, has announced that the 5-day event will be housed on the 2nd and 4th floors of the Coliseum.

AIEE TO MEET ON 4TH FLOOR

With the AIEE meeting rooms on the fourth floor, those who attend may move easily from the conference sessions to the exhibits to see actual demonstrations of the principles, procedures, and materials they have heard discussed." For scientific sessions the lecture halls on this floor are completely outfitted for sound and picture projection equipment.

RECORD ATTENDANCE EXPECTED

N. S. Hibshman, AIEE's Executive Secretary, said, "This will be the meeting place of more than 5,000 electrical and electronic engineers from all parts of the country. All signs point to a record attendance. From past registration analyses we know that these engineers are deeply involved in design, installation and development, applications, maintenance and service, sales and marketing, production, purchasing, and education."

Mr. Grebe said that every effort is being made to provide for this highly select audience an Exposition skillfully integrated with the AIEE technical sessions and reflecting the advancing technology of the electrical-electronics industry. He said applications for exhibit space are being received from manufacturers of equipment, materials, and components and from supplier and service organizations in the electrical-electronics field.

Mr. Grebe added that applications for exhibit space "are maintaining a constant pace" and that more the 33% of the available space has already been reserved.

Detailed information about the Electrical Engineering Exposition may be obtained from the Reber-Friel Company, 117 S. 17th St., Philadelphia 3, Pa.

Most recent reservations for exhibit space have been received from the following firms: Automatic Switch Company; Borg-Warner Corporation; Clark Controller Company; Cleworth Publishing Company; Collyer Insulated Wire Company; Crucible Steel Company; Cutler-Hammer, Inc.; Eaton Manufacturing Company; Electro Switch Corporation; Esterline Angus Instrument Company; Hendrix Wire and Cable Company; Lundell and Company; Magnetic Metals Company; Molecular Dielectrics; Reliable Electric Company; Rohde and Schwarz Sales Company; Standard Transformer Company, and Zero-Max Company.

300 Engineers Expected To Attend Appliance Conference

Approximately 300 engineers are expected to attend the 2-day AIEE Appliance Technical Conference on May 22-23, 1962, at the Deshler-Hilton Hotel, Columbus, Ohio.

Conference Chairman John Lieberman of Ranco, Inc., said the event is expected to attract electrical and appliance engineers from all parts of the country who work in the $5 billion industry. In addition to engineers employed by the appliance manufacturers, representatives from supplier and component firms and research groups also are expected to attend.

Details of the program are being worked out and will be announced early in 1962. In addition to two major luncheon addresses, the program will include 15 technical papers prepared by Institute members.

Committee chairmen announced by Chairman Lieberman include: Finance, John Kaltenecker, Ohio Bell Telephone Company; Meeting Facilities, Robert Palomo, Ohio Bell; Registration, John Shuler, Ranco, Inc.; Publicity, D. E. Thomson, Westinghouse Electric Corporation, and Hospitality, C. H. Hickle, Ranco.

Calendar of AIEE Future Meetings

TP—Transactions Paper
CP Syn.—Conference Paper Synopsis
CPMs—Conference Paper Manuscript
DPMs—District Paper Manuscript*

Notice to Authors Strict compliance with the "Author's Guide" will save you time, delays, and unnecessary correspondence. For a copy, write to E. C. Day, 345 East 47 Street, New York 17, N. Y.

October 2-3, 1961
ECPD 29th Annual Meeting
Sheraton Hotel
Louisville, Ky.

October 5-6, 1961
Middle Atlantic (Fall) Textile Conference†
Barringer Hotel
Charlotte, N. C.

October 9-11, 1961
AIEE-IRE-EIA-SMPTE
National Electronics Conference†
Sherman Hotel
Chicago, Ill.

October 15-20, 1961
Fall General Meeting†
Statler-Hilton Hotel
Detroit, Mich.

October 16-18, 1961
Machine Tools Conference†
Faust Hotel
Rockford, Ill.

October 26-27, 1961
AIEE-IRE-U of Nebr.
Biomedical Instrumentation and Engineering Conference†
Sheraton-Fontenelle Hotel
Omaha, Nebr.

November 6, 1961
Western Appliance Conference†
Biltmore Hotel
Los Angeles, Calif.

November 6-8, 1961
AIEE-IRE
Nonlinear Magnetics Conference†
Statler-Hilton Hotel
Los Angeles, Calif.

November 12-16, 1961
AIEE-AIP Magnetism and Magnetic Materials Conference
Westward Ho Hotel
Phoenix, Ariz.

December 10-14, 1961
AIEE-IRE-ACM
Eastern Joint Computer Conference
Sheraton-Park Hotel
Washington, D. C.
(Final date for TP—closed, CP Syn.—closed, CPMs—Oct. 6.)

January 9-11, 1962
AIEE-IRE-ASQC-EIA
National Symposium on Reliability Control
Statler Hilton Hotel
Washington, D. C.
(Final date for TP—Oct. 11, CP Syn—Oct. 26, CPMs—Nov. 6.)

January 28-February 2, 1962
Winter General Meeting
Hotel Statler
New York, N. Y.
(Final date for TP—Oct. 30, CP Syn.—Nov. 9, CPMs—Nov. 24.)

February 15-16, 1962
AIEE-IRE-U of Pa. International Solid-State Circuits Conference
University of Pennsylvania and
Sheraton Hotel
Philadelphia, Pa.
(Final date for TP—Nov. 17, CP Syn.—Dec. 8, CPMs—Dec. 19.)

March 1-2, 1962
AIEE-IRE-AEC-NBS
8th Scintillation and Semi-Counter Conference
Shoreham Hotel
Washington, D. C.
(Final date for TP—Dec. 1, CP Syn.—Dec. 15, CPMs—Dec. 26.)

April 3-5, 1962
Cement Industry Conference
St. Louis, Mo.
(Final date for TP—Jan. 3, CP Syn.—Jan. 18, CPMs—Jan. 29.)

April 4-6, 1962
South Central District Meeting
Hotel Peabody
Memphis, Tenn.
(Final date for TP—Jan. 4, DPMs—Jan. 29.)

April 9-10, 1962
Rubber and Plastic Industries Conference
Sheraton Hotel
Akron, Ohio
(Final date for TP—Jan. 9, CP Syn.—Jan. 24, CPMs—Feb. 2.)

April 10-11, 1962
AIEE-ASME-EIC
Railroad Conference
King Edward Hotel
Toronto, Ont., Canada
(Final date for TP—Jan. 10, CP Syn.—Jan. 25, CPMs—Feb. 5.)

April 17-19, 1962
Rural Electrification Conference
Fort Shelby Hotel
Detroit, Mich.
(Final date for TP—Jan. 24, CP Syn.—Feb. 1, CPMs—Feb. 12.)

April 18-20, 1962
Great Lakes District Meeting
Hotel Van Orman
Fort Wayne, Ind.
(Final date for TP—Jan. 18, DPMs—Feb. 9.)

April 30-May 2, 1962
Mid-America District Meeting
Hotel Chase
St. Louis, Mo.
(Final date for TP—Jan. 30, DPMs—Feb. 23.)

May 7-9, 1962
Middle Eastern District Meeting
Hotel DuPont
Wilmington, Del.
(Final date for TP—Feb. 6, DPMs—Mar. 2.)

May 8-10, 1962
Joint Electronic Components Conference
Mariott Motel
Washington, D. C.
(Final date for TP—Feb. 7, CP Syn.—Feb. 22, CPMs—Mar. 5.)

May 9-11, 1962
North Eastern District Meeting
Hotel Statler
Boston, Mass.
(Final date for TP—Feb. 8, DPMs—Mar. 5.)

May 14-16, 1962
Joint District Meeting
Erie, Pa.
(Final date for TP—Feb. 13, DPMs—Mar. 9.)

May 23-25, 1962
AIEE-ISA-ARS-IAS
National Telemetering Conference
Sheraton-Park Hotel
Washington, D. C.
(Final date for TP—Feb. 22, CP Syn.—Mar. 9, CPMs—Mar. 19.)

May 22-23, 1962
Appliance Technical Conference
Deshler-Hilton Hotel
Columbus, Ohio
(Final date for TP—Feb. 22, CP Syn.—Mar. 9, CPMs—Mar. 19.)

June 17-22, 1962
Summer General Meeting
Hotel Denver Hilton
Denver, Colo.
(Final date for TP—Mar. 19, CPMs—April 11.)

August 27-September 1, 1962
IFIPS Congress
Munich, Germany

* District Paper Synopses should be directed to the District Meeting Committee
† Final date for submitting papers—closed

Biomedical Engineering Conference Scheduled for October 26-27 in Omaha

A study-conference on the Role of Biomedical Engineering in Universities and Hospitals will be held October 26-27 at the Sheraton-Fontenelle Hotel in Omaha, Nebr.

Sponsors of the meeting are the University of Nebraska College of Medicine, the Electrical Techniques in Medicine and Biology Committee of AIEE, and the Professional Group on Biomedical Electronics of the Institute of Radio Engineers.

This conference will study the present and future role of biomedical engineering as a scientific resource. It will bring together representatives from universities, research institutions, hospitals, and industry. The principal feature of the conference will be four study groups meeting simultaneously to discuss major problems in the development of this field. All registrants will be assigned to the study group of their choice and will be encouraged to participate in the discussions. The work of these groups will be summarized and reported at the final session. It is hoped that the conference proceedings, which will include the reports of the study groups, will serve as a guide to further development of biomedical engineering in universities and hospitals.

The registration fee of $13 includes all sessions and lunch and dinner, Thursday, October 26.

The tentative program follows:

WEDNESDAY, OCTOBER 25

8:00 p.m. Registration

THURSDAY, OCTOBER 26

8:00 a.m. Registration

9:00 a.m. Session I The Role of Engineering in Biological and Medical Research

Welcome: Session Chairman
F. L. Dunn, Univ. of Nebr.

Biomedical Engineering in Basic Research, *W. P. Peake*, MIT

Biomedical Engineering in Clinical Medicine, *Duncan Holaday*, Univ. of Chicago

Industry's Contributions to Biomedical Education and Research, *Albert Grass*, Grass Instrument Company

The Relationship between Bionics and Biomedical Engineering, *John Lyman*, Univ. of California, Los Angeles

The Impact of Engineering Theory on Biology, *R. L. Schoenfeld*, Rockefeller Inst. & Polytechnic Inst. of Brooklyn.

12:00 noon Luncheon

2:00 p.m. Session 2 Study Groups

Four study groups will convene simultaneously. A summary of the conclusions reached by each group will be presented by the chairman during the last session of the conference.

A. Development of the Biomedical Engineer

Discussions will center around:
1. Scope of scientific training
2. Development of professional maturity in research
3. Problems of professional growth

Discussion leaders:
V. W. Bolie, chairman, Iowa State Univ.
Edwin Gordy, Roswell Park Memor. Inst.
John Lyman, Univ. of Calif., Los Angeles
L. H. Montgomery, Vanderbilt Univ.
S. A. Talbot, Johns Hopkins University

B. Research Organization of Biomedical Engineering

1. The research project
2. Departmental programs
3. Institutional facilities

Discussion leaders:
R. L. Shoenfeld, chairman, Rockefeller Inst.
John Artesani, Wake Forest College
H. Fein, University of Utah
R. E. Jones, Mayo Clinic
G. C. Riggle, National Insts. of Health.

C. Development of Research Instrumentation

1. Problems in specifications and methodology
2. Evolution from design

Discussion leaders:
S. R. Gilford, chairman, Gilford Instrum.
Donald Baker, University of Washington
Albert Grass, Grass Instrument Company
G. I. Johnston, Univ. of Oregon
William Mueller, State Univ. of N. Y.

D. Administrative Organization

1. Relation of research function
2. Problems of financing
3. Staff structure

Discussion leaders:
G. N. Webb, chairman, Johns Hopkins Hosp.
R. L. Bowman, National Insts. of Health
F. L. Dunn, University of Nebraska
Charles Schaeffer, Albany Medical Coll.
Ralph Stacy, Ohio State University

5:30 p.m. Social Hour

7:00 p.m. Informal Introduction of Committee Members and Dinner

FRIDAY, OCTOBER 27

9:00 a.m. Session 3 Discussion Group Meetings

Reconsideration of study group reports

10:00 a.m. Support Programs for Biomedical Engineering

Session Chairman:
G. C. Riggle, National Insts. of Health

Current Status of Educational Programs, *F. L. Thurstone*, No. Car. State College

Engineering-Sciences Programs, National Science Foundation

Industrial Aid to Biomedical Engineering, *L. E. Slater*, Foundation for Instrumentation Education and Research

Research and Training Grant Program Relating to Biomedical Engineering, *W. L. Koltun*, Nat'l. Insts. of Health (Title to be announced), *Miles McLennan*, NASA and NSAF Air Med.

2:00 p.m. Session 4 Reports from the Study Groups

Session Chairman:
Dennis LeCroisette, Drexel Inst. of Tech.

Study Group Chairmen:
V. W. Boile, Development of the Biomedical Engineer
R. L. Schoenfeld, Research Organization of Biomedical Engineering
S. R. Gilford, Development of Research Instrumentation
G. N. Webb, Administrative Organization

The Meeting Committee consists of the following:

Conference Chairman:
H. G. Beenken, University of Nebr.

Program Committee:
Dennis LeCroisette, chairman
Drexel Institute of Technology
F. L. Dunn, co-chairman,
University of Nebraska
G. C. Riggle, National Inst. of Health
R. L. Schoenfeld, Rockefeller Inst.
G. N. Webb, Johns Hopkins Hospital

Student Prize Paper Winners of 15 District Competitions Announced

The results of the AIEE District Student Prize Paper Competition have been announced. In addition to the $25 Institute award to the first place winner in each District, the Members-for-Life Fund provided additional prizes. These included a trip to the Summer General Meeting for the first place winners, $25 to the second place winners, and $15 to third place winners. Cash awards and certificates were prepared at AIEE headquarters.

The first, second, and third place winners in 15 Districts, their colleges, and technical paper titles are as follows:

District 1

1. W. A. Anderson, T. C. Stoiber (co-authors), University of Buffalo, "Infrared Position Servo"
2. F. McLeod, Jr., Cornell University, "A Modification of the Quine McCluskey Method"
3. R. L. Venezky, Cornell University, "Teaching Machines"

District 2

1. R. G. Chapman, Jr., Princeton University, "The Modified Coherer as a Bistable Element"
2. J. P. Bevans, Johns Hopkins University, "A Random Number Generator"
3. Lex Hughes, B. D. Dent (co-authors), Lafayette College, "Electric Chronometer"

District 3

1. Allan Ehertok, New York University, "A Survey of College Radio Carrier Current Broadcasting Facilities"
2. Joseph Squarzini, Manhattan College, "A Photo-Electro-Mechanical Control System Demonstrator"
3. R. F. Franke, Newark College of Engineering, "A Wide-Band Electronic Switch for Dual Channel Oscillographic Observations"

District 4

1. W. E. Montgomery, Duke University, "A Pulse-Sampled Video Recording System"
2. Ronald Houck, Lane Scheiber (co-authors), University of Florida, "Introduction to Boolean Algebra and Application to Nim Game Logic"
3. P. J. Thompson, Jr., Virginia Polytechnic Institute, "New Applications of the Cathode Ray Tube in High-Speed Switching"

District 5

1. J. B. Murphy, Bradley University, "Solution of Nonlinear Electrical Machine Transients"
2. P. L. Ransom, University of Illinois, "Finding the Log-Spiral, A Frequency-Independent Antenna"

(tie) L. P. Trubell, Milwaukee School of Engineering, "Strain Measurements by Employing a Telemetry System"

District 6

1. L. D. Feisel, Iowa State University, "A Remote Control System Using Pulse Position Modulation"
2. D. C. Price, South Dakota School of Mines and Technology, "Design and Construction of a Four-Digit Binary Adder"
3. D. L. Sheppard, University of Colorado, "Dielectrics for Electronics—Silicone Alloys"

District 7

1. D. W. Peterson, Washington University

(St. Louis), "A Low-Frequency Mechanical Generator"

2. H. N. Peterson, Missouri School of Mines and Metallurgy, "The Semiconductor Network Approach to Microminiaturization"

3. R. L. Best, Oklahoma State University, "Homopolar Machines"

District 8

1. R. F. Overmyer, California State Polytechnic College, "Analysis and Synthesis of a Sampled-Data Model of the Human Operator"

2. J. F. Fry, University of California (Berkeley), "The Effects of R-F Energy on the Pumping Speed of a Titanium Vac-ion Pump"

3. Jackson Hicks, Arizona State University, "Theoretical Analysis of Electro-mechanical Filters"

District 9

1. D. R. Harrison, University of Utah, "The Statistical Acceleration and Detection of Charged Micron-Size Particles"

2. W. J. Wilson, University of Washington (Seattle), "A Statistical Analysis of a Random Signal"

3. L. S. Bell, University of Idaho, "A Transistorized Multimeter"

District 10

No contest

Districts 11 and 14 Joint Student Competition

1. T. N. Trick, University of Dayton, "Measurement and Generation of Noise"

W. J. Wilson, Air Force Institute of Technology, "Electromagnetic Repulsion of Aluminum Rings"

2. D. A. Driscoll, University of Cincinnati, "Diode Function Generator"

3. G. W. Kinder, University of Cincinnati, "Pulse Modulated Microwave Communication System"

(tie) Richard Behnke, Terry Badger (co-authors), Ohio University, "An Experimental Automatic Telephone Dialer"

(tie) C. F. Brunk, Michigan State College, "Semiconductor Fabrication"

District 12

1. C. J. Neuse, University of Connecticut, "The Tunnel Diode—Its Operation and Characteristics"

2. L. E. Long, Northeastern University, "Phase Modulation Generator Design and Analysis"

3. R. H. Berube, University of Rhode Island, "The Development of a Quarternary Pulse Counter Using PNPN Silicon Controlled Rectifiers"

District 13

1. W. K. Mitchell, F. I. Treece (co-authors), University of Alabama, "A Receiver Activated Transmitter Block for Aircraft Radios"

2. W. D. Bringier, Tulane University, "A Combined Function AGC Amplifier"

3. I. C. Stanfill, University of Tennessee, "Digital Computer Simulation, IBM *1620/LG P30*"

District 15

1. F. D. Moore, Agricultural and Mechanical College of Texas, "Impedance Characteristics of Logarithmically Periodic Antennas"

2. D. L. Cannon, Texas Technological College, "Electroluminescence"

3. L. C. Thomas, University of Texas, "Quantum Mechanical Basis for the Tunnel Diode"

Educational Publications Committee Promotes Material of Interest to Students

The Educational Publications Committee of AIEE, under the chairmanship of E. T. B. Gross, research scientist, The Martin Company, is promoting the publication of material of interest to Student Members.

A few years ago, a survey was made to find out what material was wanted by students and the request for the printing of prize-winning student papers topped the list. It was then decided to consider all first District prize-winning papers and to print some. All qualified papers which were submitted to the Committee for review by the chairman of the AIEE District Committees on Student Activities were reviewed by at least three independent reviewers from outside the District of the prize paper. Selected papers were then submitted to the Editor of *Electrical Engineering* for his consideration on the basis of the original manuscript or of a new manuscript, revised in line with the reviewers' comments.

Since space limitations make it mandatory to limit the length of each article acceptable for printing in *Electrical Engineering*, the student authors were advised to consider shortening their papers during the preparation of the new manuscript. As a result, the new papers were often not only shorter but also much more to the point and greatly improved.

The good experience gained during recent years has led to new rules concerning the maximum length of prize paper manuscripts for Branch, District, and National student paper competitions. The manuscript is limited to 15 pages inclusive of the space for illustrations and tables; the pages are of the standard letter size and typed in double spacing.

Students who consider the preparation of papers for Branch competitions may wish to review some printed prize papers. The following list contains such papers published during the last few years when these policies were developed:

Analog Computer Control for Component Aircraft Machining, N. F. Kfoury. *Electrical Engineering* Vol. 76, 1957, 915-19

A Demonstration Transmission Line, C. H. Parks. *Electrical Engineering* Vol. 76, 1957, 919-21

A Method of Designing Transistor Switching Circuits, J. D. Burroughs. *Electrical Engineering* Vol. 77, 1958, 944-47

Grid-Current Measurements with a D-C Analog Computer, J. R. Cox. *Electrical Engineering* Vol. 78, 1959, 162-65

An Electronic Random Number Generator, J. A. Lauder. *Electrical Engineering* Vol. 78, 1959, 238-42

Linear-Phase Transistor Amplifier, P. Hirsch. *Electrical Engineering* Vol. 78, 1959, 1184-89

Stability in Steering Control, I. E. Sutherland. *Electrical Engineering* Vol. 79, 1960, 298-301

A Telemetering System for Stomach Pressure of Animals, R. W. Allington. *Electrical Engineering* Vol. 79, 1960, 590-93

The "Bucking Bronco" Motor as a Non-Linear Oscillator, R. M. Goldwyn. *Electrical Engineering* Vol. 79, 1960, 828-31

A Narrow-Band Peak-Clipping Speech Amplifier, R. C. Sommer. *Electrical Engineering* Vol. 79, 1960, 905-08

A Transistorized Pulse Monitor, D. M. Davies and R. L. Allen. *Electrical Engineering* Vol. 79, 1960, 915-18

A Low-Speed Thyratron Counter-Scaler Unit, O. G. Gabbard. *Electrical Engineering* Vol. 80, 1961, 189-93

A Voltage Comparator for Low-Frequency Noise Measurements, F. A. Spelman. *Electrical Engineering* Vol. 80, 1961, 200-01

Thermoplastic Recording, A. Spencer. *Electrical Engineering* Vol. 80, 1961, 439-42

Low-Frequency Parametric Amplification by Means of an Induction Machine, R. A. Elco. *Electrical Engineering*, Vol. 80, 1961, 600-04

Electrical Applications in Textile Industry Studied

Because electrical applications are constantly being changed and improved, the Conference on Electrical Applications in the Textile Industry will devote considerable time this year to new products, automation, research, and other timely subjects and their textile application. The 1961 conference will take place October 5-6 at the Barringer Hotel, Charlotte, N. C.

Electrical applications are becoming increasingly important in the efficient and economical operation of textile industry plants. The AIEE Textile Industry Committee provides a service to textile management and individuals interested in and responsible for electrical applications in their plants. Each year, a conference takes place either in Raleigh or Charlotte, N. C., where textile men can get together and share experiences and learn new approaches to old problems.

The program will be presented Thursday, October 5, from 1:30 to 5:00 p.m., and Friday, from 9:00 a.m. until 4:00 p.m. A social hour and banquet will again be included Thursday, with a luncheon Friday.

The various subjects will be presented and discussed by qualified engineers and leaders in the textile and electrical fields. A discussion will follow each topic. A list of the subjects and their authors follows:

Dollars that Management Can Save by an Engineer Value Analysis. *Robert Bunker*, Klopman Mills

Logical Approach to Automation in the Textile Industry. *C. H. Asbill*, N. C. State Coll. Textile School

Methods and Equipment Used in Locating Grounds, *J. R. Torrence*, Dan River Mills

Lighting as a Profitable Investment. *J. L. Ponzer*, chairman Tar Heel Illuminating Sections

Increase Pin Drafters Productivity with Closed Loop Electric Diffing Control. *David Josza*, Warner & Swasey Co.

Need for Research and New Innovations in the Textile Plant. *T. C. Hance*, Inst. of Textile Technology

How an Effective Survey to Determine Hours Devoted to Productivity Proved Profitable. *William Hampton*, Cutler Hammer Co.

Proposed Down Time Study from Electrical Causes in the Textile Industry. *H. E. Strock*, Associated Engg. Co.

New Products Symposium

(a) Guardister-Thermister Motor Protection. *W. S. Hines*, Westinghouse Elec. Corp.

(b) Thermo-Tector and Stato-trol or Silicone Rectifier Controlled Drives. *C. D. Beck*, General Elec. Co.

(c) Static Overcurrent Tripping Device for Low Voltage Breakers. *R. L. Winship*, Allis-Chalmers Co.

Report of AIEE Textile Committee Chairman

Future Meetings of Other Societies

17th Annual National Electronics Conference & Exhibition, Oct. 9-11, International Amphitheatre, Chicago, Ill. National Electronics Conference, Inc., 228 N. La Salle St., Rm. 2104, Chicago 1, Ill.

11th Annual Instrument Symposium and Research Equipment Exhibit, Oct. 9-13, National Institutes of Health, Bethesda, Md. J. B. Davis, National Institutes of Health, Public Health Service, Bethesda 14, Md.

ASA, 12th National Conference on Standards, Oct. 10-12, Rice Hotel, Houston, Tex. American Standards Assn., Inc., 10 E. 40 St., New York 16, N. Y.

ASSE, Annual Meeting, Oct. 16, Waldorf Room, Conrad Hilton Hotel, Chicago, Ill. American Society of Safety Engineers, 5 N. Wabash Ave., Chicago 2, Ill.

American Society of Mechanical Engineers.

ASME Materials Handling Conference, Oct. 17-18, Pick Nicolette Hotel, Minneapolis, Minn.

ASME-ASLE Lubrication Conference, Oct. 17-19, Morrison Hotel, Chicago, Ill. ASME, 345 E. 47 St., New York 17, N. Y.

NSPE, Fall Meeting, Oct. 19-21, Hotel Roanoke, Roanoke, Va. National Society of Professional Engineers, 2029 K St., N.W., Washington 6, D. C.

Institute of Radio Engineers

2nd New York Conference on Electronic Reliability, Oct. 20, College of Engineering, New York University, University Heights, New York, N. Y.

East Coast Conference on Aerospace and Navigational Electronics, Oct. 23-25, Lord Baltimore Hotel, Baltimore, Md.

International Symposium on Aero-Space Nuclear Propulsion and 8th Annual Meeting of the IRE Professional Group on Nuclear Science, Oct. 24-26, Hotel Riviera, Las Vegas, Nev. IRE, 1 E. 79 St., New York 21, N. Y.

1961 Detroit Metal Show, Oct. 23-27, Cobo Hall, Detroit, Mich. American Society for Metals, Metals Park, Novelty, Ohio.

1961 Computer Applications Symposium, Oct. 25-26, Morrison Hotel, Chicago, Ill. Armour Research Foundation, Illinois Institute of Technology, 33 W. 33 St., Chicago 16, Ill.

33rd Annual Radio Fall Meeting, Oct. 30-Nov. 1, Hotel Syracuse, Syracuse, N. Y. Electronic Industries Assn., 1721 DeSales St., N.W., Washington 6, D. C.

Overseas

International Congress of Industrial Chemistry, Oct., Bordeaux, France. Societe de Chimie Industrielle, 28, rue Saint-Dominque, Paris 7e, France.

Symposium on Power Reactor Experiments, Oct. 23-27, (Location undecided). International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria.

Results of Section Polls:

For the past 2 years, AIEE Sections have held meetings devoted to the discussion of several plans for the organization of the profession. The "Functional Plan" recommended by the Intersociety Relations Committee and the AIEE Board of Directors (*Electrical Engineering*, February 1958 issue, pp. 119-21) was compared with other proposals having the same general objective.

Those who attended the meetings were asked to express their preference by voting on the several plans described. The results of these polls, as reported by the Sections, are tabulated on the charts which follow:

Section Meeting Reports • Summary of Ballots Received

	Open Ballot						Restricted Ballot		
Sections & Subsections	Func'l Plan	Amalg Plan	Other Plan	Stat Quo	Non-Vot.	Total	Func'l Plan	Amalg Plan	Total
Akron (262)	65				1	66	65		65
Alabama (387)	65					65	65		65
Arizona (334)	92	1	3		5	101	97	1	98
Arkansas (167)							48	1	49
Northwest Arkansas (sub)	14		1	2		17	17		17
Arrowhead (81)							53	1	54
Beaumont									
Lake Charles (sub)	11	2			4	17			
Boston (1,313)	14	18	13	1		46			
Canton (115)							19		19
Central Florida (239)	39	11				50	39	11	50
Central Indiana (441)	29	14		1		44	29	14	43
Bloomington (sub)	12	1	4		1	18	15		15
Evansville (sub)	12					12	12		12
Chicago (2,260)	4					4	4		4
Cleveland (1,191)	67	2	2	2	5	78	74	3	77
Columbus (340)	27	2	19	1	4	53			
Chillicothe (sub)	1	2	19			1	8		8
Zanesville (sub)	13		3	1		17	15		15
Connecticut (967)	42			5	5	52			
New London (sub)	17					17	17		17
Corpus Christi (124)	61	2		2		65			
Dayton (344)			"Unanimous for FP"						
Delaware Bay (190)	36	3	3	4	4	50	36	3	39
Denver (621)	73	4	5			82			
East Tennessee									
Upper East Tennessee (sub)	4		17		1	22	22		22
Erie (214)	8	7	2	5		22			
Fort Wayne (200)	52	4	12	5		73	73	15	88
Marion (sub)	8		1			9	9		9
Georgia (457)							55		55
Houston (461)							36		36
Idaho									
Southern Idaho (sub)	37	1			24	62			
Iowa (202)							29	1	30
Iowa-Illinois									
Cedar Valley (sub)	14					14	14		14
Ithaca (364)	39		3	4		46	43		43
Binghamton (sub)	39		3	4		46	43		43
Lehigh Valley (511)	76	2	19	5	4	106	83	3	86
Lima (150)							56	7	63
Lynn (309)	35	5	2	1	2	45	33	3	36
Merrimack Valley (sub)	28	18	7			53	28	24	52
*Los Angeles (3,024)	852	126	6	244	7	1,235			
Maryland (955)	57	14		8	17	96			
Michigan (1,108)	69	6	6	3		84	72	6	78
Middle Tennessee (76)	30		2		2	34	34		34
Milwaukee (986)	26	11				37	26	11	37
Minnesota									
Red River Valley (sub)	8		4		4	16			
Nashville (106)	38			1		39			
*New Hampshire (183)	64	2		2		68			
New Orleans (297)	36	5	20	1		62	51	11	62
*New York (5,822)	359	39	7	33		438	42		42
Niagara Frontier (405)	24	1	6			31	26	1	27
North Carolina (602)	47	4	3	1	2	57			
Charlotte (sub)	26	4	1		4	35			
Eastern North Carolina (sub)	6			1	5	12			
North Texas (790)	75		4		4	83	75		75
North Eastern Mich. (142)	31	1	1	1		34			
Northern New Mexico (204)	38	3	8	2	1	52	46	6	52
Oak Ridge (70)	10	2		6	2	20	13	4	17
Ohio Valley (71)	21					21	21		21
Scioto Valley (sub)							5	1	6

* Mail Ballot

PROFESSION TO ACHIEVE UNITY

Section Meeting Report (Continued)

Sections & Subsections	Open Ballot						Restricted Ballot		
	Func'l Plan	Amalg Plan	Other Plan	Stat Quo	Non-Vot.	Total	Func'l Plan	Amalg Plan	Total
Oklahoma City (212)	63	4	12	5		84	79	5	84
Panhandle Plains (145)	34		4	6		44	40	4	44
Philadelphia (2,242)	71	15	4	9	11	110	78	16	94
Atlantic City Division (sub)	24	3	2	3		32	25	5	30
Pittsfield (388)	60	5	27		3	95	84	6	90
Portland (531)	46	12	4		4	66			
Richland (134)	41		2	4	3	50	47		47
Walla Walla (sub)	17					17	17		17
Rochester (338)	24	5	2	3		34	28	5	33
Sacramento (210)	22	18	2	1		43	23	18	41
*St. Louis (823)	338	61		32		431			
San Diego (338)	16	4			6	26	16	4	20
San Francisco (1,915)	95	16	12	14	6	143	110	24	134
Reno (sub)	13		1	7	1	22	14	6	20
Schenectady (846)	40	5	1	4	2	52	29	6	35
Adirondack (sub)	17	4	10	5	4	40	23	4	27
Shreveport (176)							37	4	41
Monroe (sub)			"Unanimous for FP"						
South Carolina									
Charleston (sub)	44		2			46			
South Bend (129)	38	2		2		42	38	2	40
South Texas (144)	37					37	37		37
Spokane (214)	23			2	3	28	28		28
Toledo (190)	13	5	2			20	14	6	20
Tulsa (231)	37				4	41	39		39
Utah (168)	47			1		48			
Vermont (58)	15					15			
Virginia									
Blue Ridge (sub)	28		8	1	1	38	38		38
Virginia Mountain (267)	17			3		20	20		20
Washington (1,113)							45	2	47
Worcester (134)	28		1	2		31	28	1	29
Total	4,099	474	283	450	156	5,462	2,485	245	2,730

Summary of Open Ballots • Sections and Subsections

The ballots were listed according to society affiliation. For those who are members of more than one society, the votes were tabulated more than once in this table.

Plan	AIEE Functional Plan	Amalgamation Plan	Other Plan	Status Quo	Not Voting	Total
Total Vote	4,099	474	283	450	156	5,462
AIEE	2,999	354	163	349	118	3,983
NSPE	497	29	49	27	12	614
IRE	268	33	17	54	5	377
ASEE	46	4	3	2	—	55
ASME	130	18	13	12	7	180
ASCE	33	13	2	1	2	51
AIME	8	1	1	1	2	13
AIChE	15	3	3	—	1	22
Other	103	19	32	4	9	167

Early Reports

Prior to the formal balloting summarized above, reports of meetings on this subject were received from the following Sections:

Sections (Members)	Meeting Date	Total Attendance	Vote FP/Other
Boston (1,313)	3/22	34	—
Chicago (2,260)	9/10	40	—
Columbia (sub)	2/8	32	25/32
Columbus (340)	4/5	53	27/53
East Tennessee (528)	4/28	25	25/25
Erie (214)	5/5	125	—
Florida West Coast (283)	2/4	75	—
Gulf Coast (181)	5/25	76	63/76
Hampton Roads (sub)	5/10	13	13/13
Idaho (104)	12/1	18	—
Iowa-Illinois (202)	4/5	38	30/38
Jacksonville (156)	2/8	25	19/25
Johnstown (93)	4/12	17	12/16
Kansas City (436)	3/10	32	32/32
Lehigh Valley (511)	9/18	55	—
Louisville (241)	3/18	15	—
Miami (327)	4/26	34	34/34
Mississippi (108)	5/19	24	17/24
Monroe (sub)	5/17	—	—
Montana (124)	4/7	16	1/13
North Carolina (602)	5/6	65	55/65
N.E. Wisconsin (121)	1/21	71	—
Ottawa (124)	—	—	—
Piedmont (sub)	4/14	10	10/10
Pittsburgh (1,669)	3/21	40	13/35
Providence (270)	3/22	50	17/50
Ridgway (66)	2/24	20	20/20
St. Louis (823)	1/26	185	—
San Diego (338)	2/16	26	16/26
Siouxland (sub)	4/10/58	—	—
South Texas (144)	3/24	37	37/37
Southern Arizona (91)	4/30	17	—
Wenatchee (sub)	4/5	15	14/15
West Virginia (139)	5/16	22	4/22

Foreign Visitors To Present Papers at Magnetism Meeting

Speakers from France, England, and Japan have accepted invitations to present papers at the 7th Annual International Conference on Magnetism and Magnetic Materials to be held here November 13-16.

According to N. P. Rowley, Foreign Visitor co-ordinator for the conference, papers will be presented by Dr. E. F. Bertaut, Centre d'Etudes Nucleaires de Grenoble, Grenoble (Isere), France; E. M. Bradley, International Computers and Tabulators, Ltd., Stevenage, England; Prof. M. Takahashi, Research Institute for Iron, Steel, and Other Metals, Tohoku University, Sendai, Japan, and Prof. T. Nagamiya, Oska University, Nakanoshima, Japan.

Professor Takahashi will present a paper titled "The Induced Magnetic Anisotropy of Evaporated Films Formed in Magnetic Field."

A variety of social events, tours, and fashion shows for the wives of those attending were also announced by Mrs. D. L. Fresh, chairman of Women's Activities. The activities, spread over the 4 days of the conference, will provide an opportunity for dining, shopping, and sightseeing points of interest in the Phoenix area. Items included in the program are a Western Chuck Wagon Breakfast on the desert, a tour of Frank Lloyd Wright's architectural school Taliesen West, a fashion show, and a tour of the resort city of Scottsdale, "The West's most western town."

The conference is being sponsored jointly by AIEE, the American Institute of Physics in co-operation with the Office of Naval Research, the Institute of Radio Engineers, and the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Dr. L. R. Bickford, Jr., of the Research Laboratories of International Business Machines in Yorktown Heights, N. Y., is general chairman of the conference.

31 Technical Papers Selected for EJCC Program

A record 242 papers on recent developments in computer hardware and concepts leading toward total systems control have been sifted down to 31 selected for presentation to the Eastern Joint Computer Conference (EJCC) to be held December 12-14 in Washington, D. C.

B. G. Oldfield, chairman of the Program Committee, announced that 94 individuals representing a country-wide government-industry cross section participated in the reviewing process which subjected each paper to an average of 4.2 reviews.

Dr. Jack Moshman, chairman of the 1961 EJCC, stated that for the first time in joint computer conference history, the Proceedings will be bound in a hard cover edition, and also for the first time a semi-annual computer conference will be under the sponsorship of the American Federation of Information Processing Sciences, comprising AIEE, the Institute

of Radio Engineers, and the Association for Computing Machinery.

The theme of the 1961 EJCC is to be "Computers—Key to Total Systems Control." The half-day sessions beginning on the afternoon of December 12 will be headed "Total Systems in Real Time," "Systems Simulation," "Advances in Equipment," "Communications Systems," and "Programming and Applications."

More than 60 manufacturers of computers, systems, components, and subassemblies will be represented in the Exhibition Hall during the conference, according to an estimate by J. L. Whitlock, exhibits manager.

29th Annual Meeting of ECPD Will Take Place October 2-3 in Louisville

The 29th annual meeting of the Engineers' Council for Professional Development (ECPD) will be held October 2-3 at the Sheraton Hotel in Louisville, Ky.

Participating bodies of ECPD comprise: AIEE; American Society of Civil Engineers (ASCE); American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME); American Society of Mechanical Engineers; Engineering Institute of Canada; American Society for Engineering Education (ASEE); American Institute of Chemical Engineers (AIChE), and National Council of State Boards of Engineering Examiners.

The tentative program follows:

MONDAY, OCTOBER 2

8:00 a.m. Registration and Hospitality

9:00 a. m. Council Executive Session
(Closed session for recommendations on accreditation from Education and Accreditation Committee)

9:00 a.m. Committee Meetings
Guidance
Student Development
Development of Young Engineers
Recognition
Ethics

12:15 p.m. Luncheon Meeting
Presiding: *W. L. Everitt*, President, ECPD; Dean of Engineering, Univ. of Illinois

Speaker: *A. Bronwell*, President, Worcester Polytechnic Institute
Subject: Freedom and the Creative Society

2:00 p.m. Council Forum
Welcome to 29th Annual Meeting: *W. L. Everitt*

Reports of Committee Chairmen:
Young Engineers; *John Gammell*
Guidance; *F. J. Jeffers*
Student Development; *W. T. Alexander*
Recognition; *Guy Savard*
Ethics; *W. W. Burton*
Information; *Hal Hunt*

2:30 p.m. Business Session of Council
Members of Council; Secretaries

3:30 p.m. Business Session of Council
Council Members; Committee Chairman, Secretaries

6:00 p.m. Social Hour

7:00 p.m. Banquet
Presiding: *Douglas Ragland*, Manager of Engineering, Humble Oil and Refining Co.; Member of ECPD Executive -Committee (AIME)

Annual Report to ECPD: *W. L. Everitt*

Address: Problems of the Near East
Mark Ethridge, Publisher, *Courier Journal and Louisville Times*

TUESDAY, OCTOBER 3

9:00 a.m. Morning Session
Opening Remarks: *W. L. Everitt*

Where Does Professional Specialization Belong in the Engineering Curricula?
Presiding: *Ralph Morgen*, Vice-Pres. ECPD; Pres., Rose Polytechnic Institute

Problems of the Undergraduate Curriculum
LeVan Griffis, Dean, Engineering, Rice Univ.
Open Discussion

Problems of the Graduate Curriculum
L. E. Grinter, Dean, Graduate School, University of Fla.
Open Discussion

Problems of Accreditation
William Selden, Executive Secretary, National Commission on Accrediting
Open Discussion

Effects on Industry
Lloyd Elkins, Production Research Director, Pan American Petroleum Corp.
Open Discussion

12:15 p.m. Luncheon and Afternoon Session
Presiding: *W. S. Hill*, General Electric Co., Member, ECPD Executive Committee, (AIEE)

Speaker: *Clarence Ax*, President, Ax Construction Co.
Subject: Where Are We Going In Engineering Education?

Speaker: *Thorndike Saville*, Dean Emeritus, College of Engineering, NYU
Subject: Engineering Education in Western Europe

Early adjournment has been arranged in order to allow sufficient time for through-plane departure.

The ladies' program for the meeting has been tentatively scheduled as follows:

MONDAY, OCTOBER 2

9:00 a.m. Morning Coffee

10:30 a.m. Departure for tour of parks and Farmington (Kentucky plantation life in the early 1800's)

1:00 p.m. Ladies' Luncheon
Pendennis Club (Complimentary)

2:30 p.m. Tour
Seconds Shop at M. A. Hadley Pottery

6:00 p.m. Social Hour

7:00 p.m. Annual Banquet

TUESDAY, OCTOBER 3

9:00 a.m. Morning Coffee

10:00 a.m. Departure for Howard Steamboat Museum

12:00 p.m. Luncheon at Arts Club
Tour Chairman is *Mrs. S. E. Fisher*

The Meeting Committee consists of the following:

Douglas Ragland, AIME, Meeting Co-ordinator
R. C. Ernst, AIChE, Chairman
Mrs. W. R. McIntosh, Chairman, Ladies Committee
J. Creeden, National Society of Professional Engineers, Registration Chairman
C. S. Crouse, National Council of State Boards of Engineering Examiners, at large
A. W. Daugherty, Kentucky Society of Professional Engineers, at large
S. E. Fisher, ASEE, Finance Chairman
J. C. Marks, Louisville Engineers and Scientific Society Council, Publicity Chairman
W. R. McIntosh, ASCE, Housing and Rooms Chairman
J. R. Nally, AIEE, at large
E. H. Roberts, Louisville Engineers and Scientific Society Council, Entertainment Chairman
W. J. Ryan, IRE, at large
L. M. Sala, AIChE, Luncheon Arrangements
R. E. Shaver, ASCE, Vice-Chairman
G. C. Williams, ASEE, Printing
R. D. Zucker, ASME, Social Hour

Technical Paper Deadlines for 1962 JACC Announced

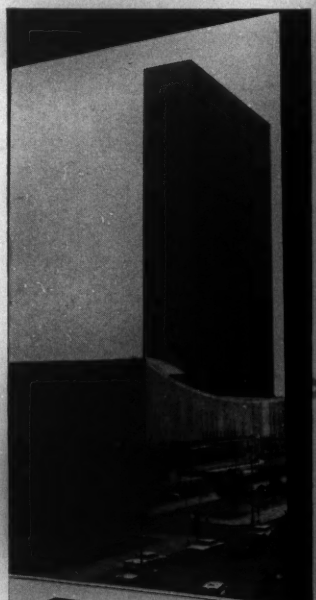
At the 1961 Boulder, Colo., Joint Automatic Control Conference (JACC), the 1962 Program Committee set the following paper deadlines for the 1962 conference: Abstracts by October 15, 1961. Paper text by November 15, 1961.

Prospective authors of significant papers covering control theory, applications, or components are invited to submit abstracts and text through their sponsoring society headquarters with the heading designation, "For 1962 JACC." Early submission is encouraged.

The 1962 JACC will be held at New York University, University Heights, New York City, June 27-29, 1962. Innovations in paper review and documentation procedures are expected to result in a program of outstanding quality.

The host university features a distinguished control engineering faculty, headed by Dean J. R. Ragazzini. The conference general chairman is Dr. A. S. Robinson, director of research, Kollsman Instrument Corporation, 80-08 45th Ave., Elmhurst 73, N.Y. A. J. Hornfeck, director of research, Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, is program chairman.

A View from UEC



Ross Photo

Looking out from one of the offices on the southeast side of the United Engineering Center (UEC) gives a view of the United Nations secretariat and general assembly buildings

AIEE Mexico Section Installs Officers for 1961-62

Jose Formoso Ferrer, the new chairman, and other officers for 1961-62 of the AIEE Mexico Section, were inaugurated recently at a meeting held in the America Club of Mexico City, Mexico. Out-

Jose Formoso Ferrer, new chairman of the AIEE Mexico Section, is shown during his inauguration speech

going Chairman Francisco Aubert swore in the new officers.

Mr. Ferrer, general superintendent of Mexican Light and Power Company, in Mexico and a registered professional engineer is a graduate in both electrical and mechanical engineering at the National Politecnic Institute of Mexico.

During his term of office, Mr. Formoso Ferrer will be assisted by the following officers: Vice-Chairman, Mr. Aubert, consulting engineer; Secretary, Jose Sanchez Zarazua, assistant general superintendent, Mexlight; Treasurer, Salvador Domenzain, electrical superintendent, Nacional Financiera; and Members of the Board—Maurice Gendreau, Francisco Hawley, Antonio Paredes Gayoso, and Alfredo Romero Ferrer.

Special committee chairmen will be chosen by their own groups and appointed to the Mexico Section, which was founded in 1922 and has now more than 350 members.

Institute To Conduct Energy Conversion Conference

The AIEE Pacific Energy Conversion Conference will be held August 13-16, 1962, at the Fairmont Hotel in San Francisco, Calif.

Outstanding authorities will be invited to speak on each of the six categories of energy that have been selected: Thermoelectric, Thermionic, MHD, Fuel Cells, Photovoltaic and Energy Storage Devices. Panel discussions on each major subject will allow opportunity for controversy and debate.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 345 East 47th Street, New York 17, N.Y.

International Relations Promoted by EJC Committee

Two members of the Committee on International Relations of Engineers Joint Council (EJC) met with foreign officials recently.

Joseph Wischeidt, Jr., secretary of the Committee on International Relations of EJC met in Paris, France, with officials of UNESCO to discuss EJC's cooperation with that organization. Mr. Wischeidt, who is also executive secretary of the United States Committee of the International Association for the Exchange of Students for Technical Experience (IAESTE), was the guest of the German National IAESTE Committee on a tour of German industries in which American students were training. His purpose was to determine the reasons for the extensive participation of German industry in this exchange, with a view toward increasing United States participation in this same program. In addition, he met with French and Austrian representatives of the IAESTE.

George Browne, chairman of EJC's Committee on International Relations, on a 2-month tour of Latin America in connection with publication interests of McGraw-Hill, consulted with officials of the Pan American Federation of Engineering Societies (UPADI) concerning the Council's international programs. Mr. Browne met with officials of the Puerto Rican Engineering Societies concerning arrangements for the 1962 UPADI Convention to be held there, and consulted with Brazilian engineers regarding closer ties between that country and the United States, as far as the engineering communities are concerned.

Mr. Browne also consulted with the Board of Directors of the Pan American Federation in Montevideo, Uruguay, to help develop projects mutual to the Americas in engineering, sanitation, transportation, and power. Prior to his departure from the United States, he has had consultations in Washington relative to the United States engineering interests and programs being developed for South America. Mr. Browne expects to develop recommendations to strengthen participation of American engineers in the future industrial development of Latin America.

Schenectady Section Joins Fund Drive for ETV Equipment

The Schenectady Section of AIEE has joined with other area technical societies

One of the first contributions to the area Joint Engineering Societies' Videotape Recorder Fund was made by Harold Fiedler (right), *chairman of the Schenectady Section of AIEE. Receiving the check is R. G. Hoft* (left), *fund-raising chairman, and R. F. Shea, committee chairman. The presentation followed an inspection of similar videotape equipment at the WAGB studio. In making the presentation. Mr. Fiedler stated that the Executive Council had voted to make this contribution from the Section funds to launch the drive among individual members*

Silver Tray Award Presented

A student at the University of Connecticut, C. J. Nuese (center) *was presented with a silver tray during the District Vice-President's luncheon at the North Eastern District Meeting in May. Mr. Nuese was the winner of the District 12 prize paper contest for students, with the paper "The Tunnel Diode—Its Operation and Characteristics." The presentation was made by Fred Bacon* (right), *who has since been replaced by L. J. Weed* (seated, at left), *who is incumbent Vice-President of the District*

to support a drive to obtain a videotape recorder for the Mohawk-Hudson Council on Educational Television (MHC-ETV).

The videotape recorder is valued at more than $50,000 and will be made available through a grant from the Ford Foundation if MHCETV can provide test equipment to insure that locally originated tapes are suitable for reproduction and distribution to other ETV stations. The test equipment, valued at $11,000 is the goal of the area Joint Engineering Societies' fund-raising drive.

This contribution, made in advance of a general fund-raising drive among civic, business, and professional groups of other areas, will enable area engineers to take the lead in helping to obtain a full-time ETV Station for the District. R. F. Shea, committee chairman, is formulating the general plan for solicitation among individual society members.

ETV can aid the engineer by keeping him abreast of new developments and new analytical tools. Through the medium of television, news of scientific interest and courses for professional self-development can be presented in prime evening time.

NET (National Educational Television) headquarters in New York maintains a vast library of videotape programs representing the best of locally originated material and the best of other oustanding program sources. There are at present more than 60 ETV stations operating in the United States. The District, with its unusually high concentration of engineering talent, can make good use of and substantial contribution to this store of educational material.

Exchange Scholars Sought for Research in Soviet Union

The Inter-University Committee on Travel Grants, representing American colleges and universities, has announced that it is soliciting inquiries and applications from graduate students and scholars who wish to spend all or part of the academic year 1962-63 engaged in study and research in the Soviet Union (USSR) as participants in the academic exchange between the United States and the USSR.

American citizens under 40 years of age are eligible if they are graduate students, post-doctoral researchers, or faculty members at the time of application. Teachers of the Russian language in secondary schools are also eligible. Persons from all fields of study are encouraged to apply, providing that they can show reasonable professional and scholarly benefit to be derived from study in the Soviet Union.

A knowledge of Russian adequate to the needs of study and research is required. Other criteria for selection include intellectual ability, maturity, emotional stability, proven scholarly competence, or indication of future professional promise, and substantial knowledge of both American and Russian history and culture.

Periods of study and research between one semester and 15 months can be arranged. Persons wishing to spend a minimum of one academic year in the Soviet Union may be accompanied by their wives. Limitations imposed by the Soviet side prevent exchange participants from taking their families with them.

Funds are available to cover all or part of the exchange participant's expenses, including maintenance of family, depending on the participant's own financial needs and resources.

For further information and applications write to: Stephen Viederman, Deputy Chairman, Inter-University Committee on Travel Grants, 719 Ballantine Hall, Indiana University, Bloomington, Ind.

Applications must be received no later than December 15, 1961, to be considered for the 1962-63 exchange.

MEMBERS IN THE NEWS

R. L. Anderson (AM '51), formerly chief engineer at Hertner Electric Company, has been named a project manager at Designers for Industry, Inc., Cleveland, Ohio.

R. O. Babcock (AM '22, M '31), manager of the transportation department of Consolidated Edison Company of New York, Inc., retired on August 1. Mr. Babcock began as a meter tester in 1916. His later assignments included installing distribution transformers and equipment, design of substations and high tension customer services, and sales technical work. He also contributed to the design of high tension installations, made efficiency studies on private electric generating plants, and helped to organize a labor pool of mechanics serving several departments. During World War II, he served in the U. S. Navy in Hawaii in charge of building, and then operating an airplane engine overhaul plant which worked on a production line basis, the first of its kind used by the Navy. On his return to Con Edison, Mr. Babcock resumed training in the Executive Development Program and, in 1948, became transportation manager.

A. D. Bailey (AM '56) has joined the staff of Technology Instrument Corporation of Acton, Acton, Mass., as senior electronic engineer in the Space Instrumentation Division. Formerly, Mr. Bailey was an assistant professor in electronic research at Northeastern University.

I. W. Best (AM '27, M '38) has retired from Allis-Chalmers Manufacturing Company as a consulting engineer in the company's Pacific Region office at San Francisco, Calif., a position he had held for the last 14 years.

R. H. Black (AM '47) has been appointed manager of the Allentown district of the Allis-Chalmers Manufacturing Company's Industries Group. Mr. Black has been with Allis-Chalmers since 1946 and had been manager of utility sales in the Philadelphia, Pa., district since 1958.

N. M. Blair (M '53), president of the RF Products Division of Amphenol-Borg Electronics Corporation, Broadview, Ill., has been named president of Amphenol-Borg's FXR Division.

C. J. Breitwieser (AM '33, M '44), a co-founder and director of Cubic Corporation, San Diego, Calif., has been elected executive vice-president and general manager of the company. Dr. Breitwieser has served on the AIEE Aero-Space Transportation Committee (1944-48, 1955-61).

Joseph Bronaugh (AM '29, M '37) has been appointed manager, utility sales, Baltimore district, of the Allis-Chalmers Manufacturing Company's Industries Group. He was formerly manager of the Cleveland, Ohio, district.

Dean Cady (AM '38) has been appointed regional manager of the James R. Kearney Corporation's newly created West Coast Region, whose office is at Burlingame, Calif. Mr. Cady was formerly with Maydwell and Hartzell, Inc.

F. E. Canavaciol (AM '18, F '49, Member for Life) is retiring from the Polytechnic Institute of Brooklyn this year after more than 30 years of educating, researching, and consulting. Prof. Canavaciol earned his bachelor's degree from Polytechnic Institute. In the field of communications, he is noted for his work with telephone equipment, receivers, measurement of circuit characteristics, and material characteristics. In the early '30's, he worked on determining the best mixture of materials in making low-loss insulators for radio operation. Out of the research and development came the first ceramic insulator created for radio. He is an AIEE representative to the Alfred Noble Prize Committee, American Society of Civil Engineers (1957-62).

A. A. Casey (M '50) has been appointed vice-president of engineering, Cleveland Electric Illuminating Company, Cleveland, Ohio. Mr. Casey joined the company in 1920.

O. P. Cleaver (AM '36, M '48) recently was promoted from lieutenant-colonel to colonel in Mobilization Designation Detachment No. 39, the Corps of Engineers' Reserve Unit at the U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va.

T. L. Cordle (M '57), associate and manager of the electric department, J. N. Pease and Company, Charlotte, N. C., has been elected vice-president of the Illuminating Engineering Society, Southeastern Region, for 1961-63.

H. W. Cory (AM '45) has been appointed to the new post of assistant general manager of Allis-Chalmers Manufacturing Company's plant at Norwood, Ohio.

D. C. Courtney (AM '57) has transferred to the Central Technical Division at Humble Oil and Refining Company's Baytown, Tex., refinery from Esso Research and Engineering Company.

R. C. Crawford (M '45) has been appointed manager of the Industrial Department of Todd Shipyards Corporation in New York. He was previously associated with the General Electric Company as manager, Utility Sales, St. Louis District.

M. G. Crosby (M '41, F '51) has been named chairman of the board and director of research of Crosby-Teletronics Corporation, Syosset, N. Y. Prior to his new appointment, Mr. Crosby was president of the corporation.

J. M. Duncan (AM '55) has been appointed manager of the North Central Region, Allis-Chalmers Manufacturing Company, with headquarters in Chicago, Ill. Mr. Duncan had been assistant general manager of Allis-Chalmers Washington, D. C., office since 1960.

H. E. Felix (AM '43, M '51) has been appointed vice-president and director of engineering at Midwestern Instruments, Inc., Tulsa, Okla. He joined the organization after 21 years of design engineering experience with Douglas Aircraft Company. Mr. Felix has served on the AIEE Aero-Space Transportation Committee (1951-53, 1956-61).

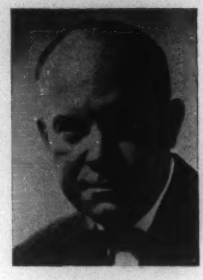
A. D. Gilchrist (AM '45, M '56) has been named to the new post of vice-president and general manager of the Alternator and Standard Products Division of the Leece-Neville Company, Cleveland, Ohio.

Herman Halperin (AM '21, F '45, Member for Life), senior staff engineer, Commonwealth Edison Company, Chicago, Ill., left Con Edison in July and now resides in Palo Alto, Calif. He intends to become a consulting engineer.

C. I. Hubert (AM '47, M '54), associate professor of electrical engineering at the U. S. Merchant Marine Academy, is the author of *Operational Electricity*, a new text that concerns itself with the theory, characteristics, applications, and mode of operation of circuits and machines.

D. R. Hull (M '48) has been elected to the Board of Directors of the MacLeod Instrument Corporation of Fort Lauderdale, Fla.

L. R. Jones (AM '47, M '56) has been appointed manager of engineering of the Dictaphone Corporation, Bridgeport, Conn. He had been assistant to the vice-president since 1956.



M. G. Crosby

Louis Kahn (M '56) has been appointed vice-president in charge of engineering for Astron Corporation, East Newark, N. J., and its subsidiaries. He was formerly associated in management and engineering capacities with Aerovox Corporation for more than 20 years.

E. N. Kather (AM '41) general manager of the Semiconductor Division of Raytheon Company, Lexington, Mass., has been elected a vice-president of the firm.

W. E. Kerr (M '37, F 48), president of the Pennsylvania Transformer Division of McGraw-Edison Company, Canonsburg, Pa., since 1952, has accepted the chairmanship of the company's Pennsylvania Lectro Management Group. **W. R. Swoish** (AM '41, M '53), vice-president and sales manager since 1949 of the Division, has been named vice-president of marketing and assigned additional responsibilities. **W. W. Renberg** (AM '52), formerly assistant sales manager, has been appointed sales manager of the Division.

B. H. Klyce (AM '45) has been appointed director of research and development for Regent Controls, Inc., Stamford, Conn. He was formerly technical director for the subscription service division of Time-Life, Inc.'s research facility in Chicago, where he supervised the installation of a facsimile transmission system.

Gabriel Kron (AM '30, F '51), consulting engineer with General Electric Company's General Engineering Laboratory, has been awarded an honorary doctor of science degree by the University of Nottingham at Nottingham, England. He is the first American to receive such a degree, according to University officials. Dr. Kron was previously awarded an honorary M.S. degree from the University of Michigan, where he earned his B.S. degree in electrical engineering.

C. W. LaPierre (AM '28, M '43) has been elected executive vice-president of General Electric, Schenectady, N. Y. Mr. LaPierre formerly was vice-president and group executive in charge of the company's Electronic and Flight Systems Group.

L. J. Linde (AM '39, F '51) has been appointed director of engineering, Industries Group, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Previously, he had been director of engineering services. He has served on the AIEE Nucleonics Committee (1959-61).

A. E. McClarren (AM '26, M '50, Member for Life), retired on July 1 from the Electric Boat Division of General Dynamics Corporation, Groton, Conn., after more than 25 years of service. During this period, he has held the positions of design electrical engineer, assistant chief electrical engineer, chief electrical engineer of the Nuclear Power Division, electrical test engineer, Shipyard Technical Organization electrical engineer, and instrumentation engineer. Mr. McClarren has accepted a position with the supervisor of shipbuilding, U. S. Navy, in Groton, as electrical supervisor for the Polaris Missile Control, Fire Control, Navigation, Nuclear Reactor Control, and Interior Communications. Mr. McClarren has served as chairman of the Connecticut Section, AIEE (1961-62) and was chairman of the New London, Conn., Subsection (1957-58).

M. H. Mehr has been named vice-president and general manager of Measurement Systems, Inc., South Norwalk, Conn., which has been formed to develop and manufacture electro-optical and infrared equipment. Mr. Mehr was formerly a group leader in the Advanced Development Section of the Perkin-Elmer Corporation, Norwalk, where he was project engineer on an infrared surveillance system and directed a portion of the development and field installation of several large telescopic camera systems.

C. S. Mertler (AM '52) has been appointed an engineering vice-president of Stevens Manufacturing Company, Inc. Mr. Mertler has been chief engineer of Stevens since 1950.

Herman Meswarp (AM '51, M '58) and **Haskins Eubank** (AM '44), formerly supervising electrical engineers of Gibbs & Hills, Inc., consulting engineer of New York City, have been made assistant chief electrical engineers for nuclear and conventional power projects, respectively, of the firm.

J. C. Michalowicz (AM '41, F '59), head of the department of electrical engineering at the Catholic University of America, is taking a year's leave of absence in order to serve as assistant program director in the Office of Institutional Programs at the National Science Foundation.

F. G. Miller (M '46) has been appointed director of operations of Minneapolis-Honeywell's Electronic Data Processing Division. He was formerly director of the operations engineering department.

F. M. Miller (AM '58) has been appointed superintendent of the electric department at Dravo Corporation's plant, Neville Island, Pa. Mr. Miller joined

Dravo in 1957 as electrical superintendent on iron ore sinter plant construction projects.

J. D. Mitchell (AM '40, M '54) of Chamblee, Ga., has been elected 1961-63 vice-president of the Illuminating Engineering Society (IES). Mr. Mitchell is region engineer, South Eastern Region, Lamp Division, Westinghouse Electric Corporation. He has been a member of IES since 1939 and was 1952-53 chairman of the Georgia Section and 1955-57 vice-president of the Southern and South Eastern Regions. He also has served as a director of IES and as 1960-61 general secretary.

D. E. Moat (AM '29, M '39) has been named vice-president of government and foreign relations for Leeds and Northrup Company, Philadelphia, Pa. Mr. Moat has served on the AIEE Recognition Awards Committee (1958-61).

R. M. Mock (AM '44) has been elected a member of the Board of Directors of the Digitronics Corporation, Albertson, L. I., N. Y. Mr. Mock is chairman of the Executive Committee of Lear, Inc.

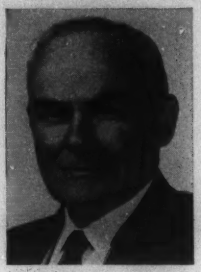
A. M. Musgrove, Jr. (AM '30, F '45), U. S. Air Force regional civil engineer, South Atlantic Region, has been installed as president of the Atlanta Post of the Society of American Military Engineers.

W. L. Newmeyer (M '34, F '48), Bureau of Reclamation electrical engineer, retired April 30 after more than 27 years of Government service. Mr. Newmeyer participated in the planning and design of some of the Bureau's largest hydroelectric projects, which include the power development at Hoover, Grand Coulee, and Shasta Dams. In 1946, he served as a member of a United Nations team which visited Greece and prepared a report on the power resources of that nation. In 1954, he was a special adviser to the Government of Uruguay on plans for hydroelectric projects. Mr. Newmeyer entered service in the Bureau of Reclamation, Denver, Colo., as an electrical engineer in 1933. In 1946, he was transferred to Washington and served on the Commissioner of Reclamation's staff in the Division of Power Utilization. In 1954, he returned to the commissioner's office in Denver where he was in charge of the maintenance of the Bureau's power developments.

R. V. Nicolson (AM '56) has been appointed supervising laboratory engineer for the Electrical System Equipment Division of Detroit Edison Company, Detroit, Mich. He was formerly a senior engineer.

H. E. Nissel (AM '49), long-time public utility consultant, has been made a vice-president of Middle West Service Company, Chicago, Ill.

E. C. Numrych (AM '55) has been appointed district sales manager for General Electric's power tube department. Mr. Numrych will operate out of General Electric's Central Sales Region headquarters in Chicago, Ill. He was formerly a specialist in product planning and application engineering for microwave tetrodes in the power tube department.



W. L. Newmeyer

C. T. Ohrn (AM '45, M '53) has been appointed general manager of Cape and Vineyard Electric Company, New England Gas and Electric System, effective October 1. He was formerly superintendent of transmission and distribution at Cape and Vineyard.

J. M. O'Rourke (AM '58) has been promoted to sales manager, Farnas Electric Company, Batavia, Ill. Mr. O'Rourke was formerly manager of original equipment marketing.

H. S. Osborne (AM '10, F '21, Member for Life) will be a guest of honor of the Academy of Achievement on the Monterey Peninsula, Calif., during the week end of September 8-10. He will receive a Golden Plate award when he takes the spotlight at the Banquet of the Golden Plate to represent achievement in his field of endeavor. Dr. Osborne has served as an AIEE president (1942-43) and director (1938-42).

C. W. Parker, Jr. (AM '48) has been named to the newly created position of general marketing manager, new products department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Mr. Parker had been director of sales promotion, Allis-Chalmers' Industries Group, since 1958.

J. O. Pease (AM '45) has been appointed commercial vice-president, Rumsey Electric Company, Philadelphia, Pa. He will continue as manager of the Rumsey Washington District Office.

E. F. Peterson (AM '33, M '45) has been elected vice-president of marketing, consumer and industrial products, International Telephone and Telegraph Corporation, New York, N. Y. Associated with the General Electric Company for 27 years, Mr. Peterson assumes his new post after serving as manager of the consumer goods export department of the International General Electric Company Division.

E. W. Petoskey (AM '60), a former district planning engineer, Detroit Edison Company, Detroit, Mich., has been named assistant to the senior planning engineer of the general engineering department. **V. J. Andres** (AM '55) was promoted from planning engineer for the west Detroit area to planning engineer responsible for distribution and transmission planning in areas of Wayne, Monroe, Washtenaw, Livingston, and Ingham counties.

N. V. Petrou (AM '43, M '50), previously manager of engineering of the Air Arm division of Westinghouse Electric Corporation, Baltimore, Md., has been named general manager of the division.

H. T. Pichal (M '59), has been appointed staff engineer of Trak Microwave Corporation, Tampa, Fla. He was previously project and staff engineer of Electronic Communications, Inc., St. Petersburg, Fla.

H. F. Pierce (AM '39, M '49), Miami, Fla., has been elected vice-president, Southeastern area, of the National Society of Professional Engineers, Mr. Pierce is a member of the firm of Maurice H. Connell & Associates, Inc., and a partner in Connell, Pierce, Garland and Friedman, architects and engineers. He has served on the AIEE Professional Conduct Committee (1957-61).

Noel Pike (AM '25, M '32) retired on April 30 after 3 years as chief executive of the Cía. Colombiana de Electricidad, Barranquilla, Colombia, an associated company of the American and Foreign Power Company Inc., and 17 years of service with the Foreign Power affiliate in Mexico, Cía. Impulsora de Empresas Elétricas.

Z. W. Pique (M '49) has been elected vice-president—marketing of Statham Instruments, Inc., Los Angeles, Calif. He has been associated with Hoffman Electronics as vice-president—marketing.

C. P. Porterfield (AM '55), former vice-president of Method X Division of Firth Sterling, Inc., of Pittsburgh, Pa., has been named director of sales for Elox Corporation of Michigan.

J. A. A. Raper (AM '53) has been appointed manager of advanced circuits and integrated electronics of the General Electric Company's Electronics Laboratory in Syracuse, N. Y. Mr. Raper was formerly manager of integrated electronics development at the Electronics Laboratory. **J. J. Suran** (AM '50, M '59) has been appointed manager of electronic devices and applications at General Electric's Electronics Laboratory in Syracuse. Mr. Suran was formerly manager of advanced circuits at the Laboratory.

H. F. Rees (AM '54) and **E. O. Berg** (AM '53), both of Huntsville, Ala., have been named chairman and secretary, respectively, of the new AIEE North Alabama Section. The new Section includes the counties of Colbert, DeKalb, Franklin, Jackson, Lauderdale, Lawrence, Limestone, Madison, Marion, Marshall, and Morgan.

J. W. Roberts (AM '46) has been transferred to the South East region office of Allis-Chalmers Manufacturing Company, Atlanta, Ga., as regional representative for electrical transmission and distribution equipment. He was formerly manager of the Chattanooga, Tenn., district. **Joseph Bronaugh** (AM '29, M '37), formerly manager of the Cleveland, Ohio, district, has become manager of utility and sales in the Baltimore, Md., district.

J. W. Robinson (AM '37, M '47) has become a joint managing director of Leeds and Northrup, Ltd., of England, and a vice-president of the Leeds and Northrup Company of Philadelphia, Pa. He was formerly president and general manager of Leeds and Northrup, Canada, Ltd., and a director of the company. Mr. Robinson has retained his directorship.

H. L. Saums (M '51), consulting engineer for magnet wire at the Anaconda Wire and Cable Company's Magnet Wire Research and Development Laboratory, has received an honorary electrical engineering degree from South Dakota State College. This was the first such degree ever awarded by the Brookings, S. Dak., institution. Mr. Saums has spent the last 30 years in magnet wire technical research and development work for Anaconda. He helped establish the Magnet Wire Laboratory 11 years ago and was its director until recently when he was relieved of routine administrative duties in order that his full time could be devoted to experimental and development work on high temperature conductors and insulations. Mr. Saums has served on the AIEE Electrical Insulation Committee (1955-61).

D. T. Scag (AM '55) has been appointed assistant director of research, Allis-Chalmers Manufacturing Company's Research Division. Since 1957, Mr. Scag had been technical director of C Stellarator Associates, Princeton, N. J., where he was responsible for technical designs and development research investigations in the Allis-Chalmers portion of the project.

L. L. Smith, Jr. (AM '50) has been named manager of sales planning for Motorola Semiconductor Products Inc., Phoenix, Ariz.

H. P. Sleeper (AM '22, F' 49, Member for Life), operating engineer, electric distribution department, Public Service Electric and Gas Company of Newark, N. J., retired June 30 after 36 years of service with the company. He came to Newark in 1925 as protection engineer in the electric distribution department of Public Service and was responsible for modernizing the protective relay system. In 1929, he was appointed engineer of transmission, and in 1940, operating engineer; he was responsible for general office functions pertaining to operation and maintenance of substations and switching stations in the electric distribution department. Mr. Sleeper was awarded the Thomas N. McCarter Electric Award in 1945, presented by Public Service in recognition of leadership in the development of relay protection for the Transmission and Distribution System of the company. He has served on the AIEE Relays Committee (1948-61).

H. P. Sleeper

G. W. Spencer (AM '52) has been named engineering manager of Erie-Pacific Division of Erie Resistor Corporation, Hawthorne, Calif. In his work on the Erie-Pacific line of digital counting and control systems, Mr. Spencer is responsible for all engineering development including basic circuitry, logic design, and mechanical engineering. Prior to joining Erie-Pacific, Mr. Spencer was engineering supervisor of a Minuteman Test Requirements and Evaluation Group at North American Aviation Autonetics Division in Downey, Calif.

J. H. Spraggon (AM '28), Westinghouse Electric Corporation, was among those executive reservists in the electric equipment manufacturing industry who were invited to Washington to participate in a National Defense Executive Reserve Conference called by the Business and Defense Services Administration of the U. S. Department of Commerce on May 23-24.

A. H. Sullivan, Jr. (AM '40, M '47), formerly vice-president of Engleman and Company, Inc., and project director of C-E-I-R, Inc., has been named director of advanced systems development at Frederick Research Corporation, Wheaton, Md.

Karl Uffelman (AM '51) has been appointed general foreman of the Power Division at the Colorado Fuel and Iron Corporation's Pueblo plant. Mr. Uffelman served as maintenance and engineering foreman from 1960.

F. C. Young (AM '24, F '45), senior partner of Young Associates, Rochester, N. Y., and vice-president of Designers for Industry, has been elected president of the Rochester Engineering Society.

C. J. Weber (AM '54) has been named assistant manager, and **A. C. Chiazza** (AM '46), sales manager of the Westinghouse aerospace electrical department at Lima, Ohio. Mr. Weber was formerly manager of contracts administration; and Mr. Chiazza, manager of the department's negotiation section and of apparatus sales.

B. O. Weinschel (M '56) has been appointed chairman of the Protection of Proprietary Rights Committee, Industrial Instrument Section, of the Scientific Apparatus Makers Association. Mr. Weinschel is head of Weinschel Engineering, Kensington, Md. He has served on the AIEE Electronic and High Frequency Instruments Committee (1960-61).

K. R. Wendt (M '52), a pioneer in the field of television development, has joined the staff of Colorado Instruments, Inc., Broomfield, Colo., as vice-president in charge of engineering.

R. L. Westbee (AM '36), vice-president, Minnesota Mining and Manufacturing Company, has been elected vice-chairman of the Insulating Materials Division of the National Electrical Manufacturers Association. The following officers were elected by the product sections within the Division: Coated Electrical Sleeving Section, chairman—**W. H. Bentley, Jr.** (AFFIL '58, president, Bentley-Harris Manufacturing Company. General Engineering Committee, chairman—**W. J. Dwyer** (AFFIL '54), executive vice-president, Suflex Corporation. Decorative Laminate Section, Technical Committee, chairman—**C. B. Leape** (AM '52), engineering manager, Micarta Division, Westinghouse Electric Corporation. Manufactured Electrical Mica Section, chairman—**E. O. Hausmann** (AM '29), vice-president and technical director, Continental-Diamond Fibre Corporation. Flexible Electrical Insulation Section, chairman—**L. N. Smith** (AM '42, M '56), chief electrical engineer, New Jersey Wood Finishing Company. Mr. Smith was also elected to the Insulating Materials Division's Board of Directors representing the Flexible Electrical Insulation Section. Mr. Bentley and Mr. Hausmann were re-elected to the Insulating Materials Division's Board of Directors.

R. D. Wilhite (AM '53), vice-president of Orange and Rockland Utilities, Inc., Nyack, N. Y., has been elected to the board of directors of the company.

E. M. Williams (AM '40, F '58), professor and head of the department of electrical engineering, Carnegie Institute of Technology, has been elected a member of the board of directors of Electronic Associates, Inc., Long Branch, N. J. Dr. Williams has served on the AIEE Fortescue Fellowship Committee (1958-61).

OBITUARIES

Lloyd Nash Robinson (AM '13, F '25, Member for Life), retired electrical engineer, Seattle, Wash., died recently at the age of 73. He was born February 26, 1888, in Watervliet, N. Y. Mr. Robinson received his B.E. degree in electrical engineering in 1911 from Union College, and the M.S. and Ph.D. degrees in electrical

engineering from the University of California in 1917 and 1919, respectively. He was a private consulting engineering in Seattle, before his retirement in 1954. Mr. Robinson was a member of Sigma Xi and served as chairman of the AIEE Seattle Section in 1929-30.

Phillips Studio

L. R. Gaty

Lewis Rumsey Gaty (AM '39, M '43, F '50), vice-president in charge of engineering and research, Philadelphia Electric Company, Philadelphia, Pa., and a prominent nuclear scientist, died August 29. Mr. Gaty was born August 21, 1902, in West Orange, N. J. He was graduated from Cornell University in 1924 with a degree in electrical engineering. That year, he joined the utility as a junior engineer. After occupying various supervisory positions within the company, he was appointed manager of the engineering department on July 1, 1948. In 1956, Mr. Gaty was elected vice-president of the company's research and development department and, in 1960, vice-president of engineering and research. He was active in the field of nuclear power development as a vice-president of the High Temperature Reactor Development Associates, vice-president and member of the technical and engineering committee of Atomic Power Development Associates, and a member of the technical and engineering committee of the Power Reactor Development Company. Mr. Gaty was a member of the Nuclear Engineering Division of the American Institute of Chemical Engineers, American Nuclear Society, American Society for Engineering Education, American Society of Mechanical Engineers, Association of Edison Illuminating Companies, Edison Electric Institute, Pennsylvania Electric Association, Pennsylvania Society of Professional Engineers, National Society of Professional Engineers, Pennsylvania Gas Association, American Gas Association, Franklin Institute, Engineers Club of Philadelphia, Cornell Society of Engineers, and Engineering College Council of Cornell University. He has served on the following AIEE Committees: Board of Directors (1958-59), Power Transmission and Distribution (1941-44), Management (1953-58, chairman 1955-58), Planning and Co-ordination (1954-58), Research (1955-61), Technical Operations (1955-58), Professional Development and Recognition Department (1956-57), and Publications Department (1957-62), chairman 1957-59), and was AIEE representative on the Atomic Energy Commission Advisory Committee on Industrial Information (1957-58).

SUMMARIES OF AIEE PAPERS

Beginning with this issue, Electrical Engineering will publish each month authors' 75-word summaries of all serially-numbered papers sold at General and District Meetings. This new service has been started with a view toward providing a complete publications service. Preprints of these papers may be purchased at 50¢ each to members, $1.00 to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 345 E. 47 St., New York 17, N. Y.

CP61-1103 — **Use and Availability of Outage Records in the Planning of System Generating Plant Additions.** *H. A. Adler, E. S. Loane* — The use of probability methods in determination of generating capacity requirements is now an accepted procedure in the system planning of many companies. Probability methods can also be applied to advantage in evaluation of spare equipment in individual installations. Various methods of application are available, but in all cases the basic need is an adequate record of unit or component outages. A method of data collection is proposed for a broad range of methods and problems in optimized design of the entire system as well as of individual units.

61-1010 (III) — **Report of Methods of Measurements for the Application of Power Line Carrier.** *Methods of Measurements Subcommittee, AIEE Power System Communications Committee* — The effective application of carrier for reliability under all conditions of power system variabilities of operation and equipment requires precise knowledge of power system conditions and characteristics of terminal carrier equipment. New developments and practices, plus the continual complexing of transmisison systems by additional paralleling circuits, line taps, etc., made it desirable to update a similar report written in 1948.

61-1011 (III) — **Proposed Standard for Power System Communication Apparatus.** *AIEE Equipment Design Standards Subcommittee Number 6, AIEE Power System Communications Committee*—The proposed standards cover usual and unusual service conditions for power system communication apparatus similar to those already established for relays associated with power apparatus (ASA C37.1) and automatic station control supervisory, and telemetering equipments (ASA C37.2). The standard excludes carrier coupling capacitors and line traps, radio antennas, and various end devices such as protective relays, supervisory control apparatus, and telemetering instruments. The standard covers usual and unusual environmental service conditions; nominal voltage ratings; allowable voltage and supply frequency variations and ripple; and insulation withstand voltage levels.

61-1012(I) — **Data System Tests Using Simulated Transmission Impairments.** *F. T. Andrews, Jr.* — Test instrumentation has been developed for simulating the principal types of transmission impairments to be encountered on voice frequency telephone circuits. These impairments include delay and attenuation distortion, frequency shift, phase and amplitude hits, interfering tones, and noise. By using this equipment together with conventional random data signal generators and error comparators, it is possible to evaluate data systems over a wide range of transmission characteristics.

61-1014 (III) — **A Further Look at Cost of Losses.** *C. J. Baldwin, C. H. Hoffman, and P. H. Jeynes* — The incremental cost to supply a small incremental peak loss is shown to be substantially less than the average cost per kilowatt of installed capacity. The major source of the difference lies in the behavior of revenue requirements for generating stations, some of which are advanced by the incremental peak load, while others are not. A varying discount is suggested for both generation and transmission depending on the amount of loss in question and the expansion pattern anticipated.

60-1015 (III) — **Analog Computer Production Testing of Electric Utility Voltage Regulators.** *G. S. Chambers, L. J. Lane,* and *A. S. Rubenstein* — A new production-testing facility utilizing an analog computer to help test voltage regulators and excitation systems and, thereby, reduce installation time, is described. Field tests and factory tests are indicated to show the accuracy of the computer simulation. An appendix thoroughly discusses theory of analog computers.

61-1016 (III) — **Recent Developments in Amplidyne Regulator Excitation Systems for Large Generators.** *G. S.*

Chambers, A. S. Rubenstein, and *M. Temoshok* — Recent improvements in amplidyne regulator excitation systems are discussed in the paper. These developments are shown to provide improved performance and to enable extension of this type of system to larger machines and to machines with high excitation voltage response requirements.

61-1017 (III) — **A Static Excitation System for Industrial and Utility Steam Turbine-Generators.** *L. M. Domeratzky, A. S. Rubenstein,* and *M. Temoshok* — A new type of static excitation system for large generators is described and its application features are discussed. The component and performance specifications to which the equipment is built are enumerated and the results of tests are presented to indicate that the design and performance objectives have been accomplished.

61-1018 (III) — **Design and Tests of a Static Excitation System for Industrial and Utility Steam Turbine-Generators.** *L. J. Lane, D. F. Rogers,* and *P. A. Vance* — A description of the theory of operation and an equivalent circuit of a new static excitation system for large generators are given. Design considerations, including protective features and rectifier cooling system design, are discussed. Factory qualification tests performed to confirm the design procedures are listed.

61-1019 (III) — **Safe Clearances and Protection Against Shocks During Live Line Work.** *A. Elek* and *J. W. Simpson* — An equation is developed to determine the limit of approach to live parts of transmission lines, based on the highest switching surges and including safety factors. The effect of temporary protective gaps is shown. The mechanism of shocks experienced by linemen during loose contact with a tower is discussed and it is concluded that such shocks are harmless but annoying and can be eliminated by introducing conducting shoes for live line work, especially on extra-high-voltage lines.

61-1021 (III) — **Retirement Problems in Generation Expansion Planning.** *C. J. Baldwin, C. H. Hoffman, and P. H. Jeynes* — Percentage revenue requirements are shown to change little as generating plant service life estimates are varied from 35 to 65 years. However, early retirement of old plants may affect the schedule of new additions in a long-range expansion pattern. In general, lowest present worth of all future revenue requirements is obtained by keeping old plants in service. Individual exceptions may exist because of transmission costs or site value for particular units. Optimum retirement date is shown to be an insensitive function of fixed operation and maintenance expenses for a particular unit.

CP61-1022 — **Circuit Analysis of Single-Phase Induction-Motor Theories.** *R. E. Bedford* — Dynamic circuit theory is utilized to examine critically the cross-field and double-revolving field theories of the single-phase squirrel-cage induction motor. Voltage-current and torque equations are deduced and equivalent circuits presented. In the transient state only the cross-field theory yields a good physical model. However, rotor resistance variation due to double-frequency rotor currents can be satisfactorily accounted for only by the double-revolving field theory.

61-1025 (III) — **Determination of an Optimum Generator Expansion Pattern.** *R. J. Fitzpatrick* and *J. W. Gallagher* — A series of programs developed for a small-scale digital computer, such as the IBM *650,* to optimize the selection of future generating capacity additions are discussed. Two programs are treated in some detail showing how the annual load duration curve has been adapted to propagate a series of new generator requirement curves. These curves, giving the new generation needs by type for future years, are then available for use in other programs mentioned which develop real expansion patterns and all costs associated with them.

61-1026 (III) — **The Importance of Fretting in Vibration Failures of Strand Conductors.** *William G. Fricke, Jr., and C. B. Rawlins* — Surface fretting between conductor strands and support hardware plays an important part in the occurrence of conductor fatigue failures resulting from aeolian vibration. Examination of conductor strand failures from lines in service and from laboratory spans showed that fatigue cracks originated at fret marks in all cases. Laboratory fatigue tests indicate that fretting causes a reduction in the fatigue strength of conductor strands, below that of unfretted wires, by a factor of about 0.6.

61-1027 (III) — **Radio Influence Testing on 70 Miles of 345-Kv Horizontal Bundle Conductor.** *R. E. Graham* and *C. R. Bond* — Radio influence test results on 75 miles of 345-kv transmission line are presented. The design of the 345-kv transmission line using 954 MCM ACSR conductor bundled at 18-inch spacing, the use of standard suspension clamps, triangular space plates, and a horizontal phase spacing of 27 feet, resulted in the satisfactory radio influence level without control rings at the conductor hardware assemblies. Attenuation tests show that radio influence readings at one site are not materially affected by precipitation on the line a distance of a few miles away at another site.

61-1028 (III) — **Stability Limits of Synchronous Motors During Power System Disturbances.** *L. Hannakam* and *C. Concordia* — Curves are presented giving the stability limits of industrial synchronous motors as a function of the magnitude and duration of power system disturbances. A range of system impedances and motor rotary inertia is covered. The performance equations in a form suitable for solution on an analog computer are included.

61-1029 (I) — **A New Billing and Collection System Using Teletypewriter Techniques.** *Eugene W. Henches* — Preparation each month of customers' telephone bills, and processing the bills after payment, are tremendous jobs. A new billing and collection procedure has been developed which combines a standard punched-card accounting system with recently developed teletypewriter and optical scanning equipment. This extended mechanization, now in operation, has made possible more efficient methods and has effected substantial savings. It can be adapted to other billing systems.

61-1032 (III) — **Control System Design for Operating Stations.** *J. G. Noest* and *G. S. Storms* — The design of d-c control systems for generating stations built on the "unit" principle is discussed from the standpoint of segregation, reliability, and continuity. By localization of the d-c control circuit and the use of an interposing 48-volt direct-wire supervisory system, exposure to failure is minimized and provision for local control is retained so that local control permits emergency operation in case of the loss of control panels, circuits, or other central control room equipment.

61-1033 (III) — **Proposed New Breaker Ratings and Their Effect on Application for Industrial Systems.** *A. H. Knable* — Simplified breaker application to industrial systems is proposed. Multiplier curves and tables provide the answer. These curves were developed by superimposing calculated induction motor fault currents on synchronous-machine-source fault currents, and by adding "*k*" factor curves which are an indication of the momentary limits of the breaker. Built-in asymmetrical capability allows breakers to be applied to industrial systems independently of breaker-rated interrupting time. One E/X calculation is adequate for breaker application.

CP61-1034 — **An Electrically Controlled Crossbar Switching System.** *R. W. S. Kinsey* and *J. E. Flood* — A telephone switching system with electromechanical switches can use a single marker to set up calls one at a time and yet handle the traffic of a large, busy central office. The switches are arranged in groups, each associated with a common-control circuit having an electronic memory. This enables the operating times of the switches to exceed the permissible holding time of the marker. A crossbar system designed on this principle is described. Each link frame has a common control containing circuits using cold-cathode gas tubes and magnetic amplifiers. Markings are transmitted between common-controls by d-c signals coded on groups of wires. A model of the system was constructed and tested. The times taken for allocating a register to a calling line and for selecting a path to a called line were each less than 20 milliseconds.

61-1035 (III) — **A Review of NESC Wind Load Requirements with Relation to Conductor Diameter.** *R. L. Retallack*

— The National Electric Safety Code (NESC) wind-loading requirements contain inconsistencies for the heavy and medium loading districts. These inconsistencies, for utilities that use NESC loads as design loads, can result in underdesigned transmission line structures—especially for large-diameter conductors. These inconsistencies are caused by a wind acting on an ice-coated conductor. The NESC light loading requirement provides a minimum working limit that guards against values for the larger conductors becoming too low.

61-1036 (III) — **Use of the A-C Network Analyzer and Electronic Differential Analyzer in the Study of Load-Frequency Control.** *G. G. Richardson and T. C. Wang* — This paper describes a study of control action on power systems using a network analyzer and an electronic differential analyzer (EDA). The approach is possible with the use of components on the Bonneville Power Administration's analyzer, which automatically adjusts phase angles of the generators in response to a system disturbance. Although this equipment is primarily for use in stability studies, it permits study of control problems through the use of an EDA on which the control transfer functions are represented.

61-1037 (III) — **Pressure-Type Connectors for Aluminum and Copper Conductors.** *N. Shackman and R. W. Thomas* — A study of the connection to aluminum conductor indicates that high pressures are required to effect a satisfactory connection and that relative movement between strands during tightening greatly assists in reducing contact resistance. A properly designed connector will incorporate means for applying high pressures with considerable distortion of the conductor. Heat-cycling tests which included mechanical stressing were found to be valuable in comparing designs. An aluminum-bodied connector with an aluminum screw gave satisfactory performance with both copper and aluminum conductors.

61-1038 (III) — **Generalized Temperature Standards for A-C Motors.** *C. G. Veinott* — This paper outlines and discusses the engineering basis for some new NEMA standards on temperature ratings for a-c motors, including the new insulation class *F*, as well as a wider range of ambient temperatures. It is further suggested that temperature rises be based on service factor load, that obsolescent thermometer-rise values on the name plate be replaced by insulation class and maximum ambient temperature for which the machine is designed.

CP61-1042 — **Small Crossbar CDO's.** *J. W. Gaiser* — Telephone people are realizing that a fast switching system is required for the smaller exchanges as well as the metropolitan areas. This need is being met by North Electric Company by using a by-path crossbar system which is built in a modular arrangement. An outstanding feature is the number group which provides unrestricted number assignment and full flexibility of relocating lines with a single wire jumper and 100-per-cent intercept.

CP61-1045 — **A Study of Use of Aluminum Guyed Towers for Extra-High-Voltage Transmission Systems.** *L. H. J. Cook and B. Cooper* — Detailed studies carried out by the authors indicate that for the topographic conditions in Central British Columbia the use of guyed transmission structures offers worth-while savings over use of conventional self-supporting towers for extra-high-voltage transmission systems. However, the self-supporting tower is recommended for the mountain sections of British Columbia. The advantages and disadvantages of both types of structure are considered, together with a description of a series of tests carried out on a guyed aluminum tower to determine erection methods and costs, and to evaluate stability under various loading conditions.

61-1046 (I) — **A Stitched Wiring Process for Miniaturized Communication Electronics.** *John M. Coffin* and *L. B. Johnson* — The advent of solid-state components led to the development of a manufacturing process known as stitched wiring. The process permits automatic and semiautomatic fabrication while maintaining excellent standards of reliability. Further, it affords a degree of repairabliity comparable to more conventional wiring. The process and the novel circuit-board fabricating technique are described and how an automated assembly line is adapted to stitched circuit board production is shown.

61-1050 (I) — **Coded Feedback Communication Systems.** *J. J. Metzner and K. C. Morgan* — The conventional approach to coding for error correction is often impractical because of the required equipment complexity and the system vulnerability to changes in channel conditions, such as fading or burst-type noise. These problems can be solved by employing long codes with feedback, correcting only small numbers of errors, and utilizing appropriate feedback techniques. The resulting system yields essentially error-free performance under all conditions, is relatively efficient, and compares very favorably in cost.

61-1051 — **Signal Flow Graph Theory for Linear Time-Variable Systems.** *E. B. Stear, A. R. Stubberud* — Techniques are presented for the analysis of linear, time-variable systems through signal flow graph concepts. These techniques are based on the combinatorial properties of linear differential equations. The concepts of stability and sensitivity of linear, time-variable systems which are described by linear differential equations are discussed. A linear, time-variable feedback system is analyzed to aid in clarifying the techniques presented.

CP61-1052 — **Tunnel Diode Static Inverter.** *J. M. Marzolf* — A simple static inverter circuit consisting of two tunnel diodes and a transformer wound on a square-loop magnetic core is described. This circuit provides a practical method for stepping up voltages of the order of 0.2 volt to practical values and is proposed for use with thermoelectric, thermionic, or fuel cell generators. The output is a very good a-c square wave.

61-1057 — **The Breakeven Cost of Peaking Capacity.** *F. M. Heck, Jr., Charles Morrison* — By generalizing and expressing as an equation the significant quantities in any relationship it can be made apparent just how each term influences the answer sought. In this paper a mathematical treatment is developed to define the economic balance between generating capacity having differing first costs and differing operating costs. This is done in terms of annual carrying charges, production costs, and spinning capacity credit. The method is applied to the economics of low first-cost, high operating-cost capacity, sometimes called peaking capacity.

CP61-1058 — **Design Development for Safer Press Controls.** *E. F. Drake* — New press control circuits for mechanical presses have been developed which will help to insure maximum production by providing additional safety to personnel and additional protection to the presses. New features to be described include: antirepeat protection during entire press cycle, checking of antirepeat circuit during each press stroke, and protection against short-circuited run buttons. Safety was the prime factor considered in the circuit design of these new features.

CP61-1059 — **Improving Transient Stability by Use of Dynamic Braking II.** *W. H. Croft, R. H. Hartley* — Selected data from the latest studies on dynamic braking as applied to the 292-mile Arizona Public Service Company's 345-kv transmission line from the Four Corners Plant to Phoenix is presented to show the effect of 4-cycle as compared to 5-cycle fault-clearing time, the effect of 4-cycle as compared to 5-cycle resistor insertion time, and the effect of changes in line and transformer impedances.

CP61-1070 — **The NX1 Exchange Trunk Carrier System.** *T. G. Fellows, A. Curran* — It was found that while the operating characteristics of the compandored N1 Carrier System made it suitable for Canadian exchange trunk applications, the cost was too high to prove it in at the distances required. Channel units and some of the common equipment were redesigned. The main saving was achieved in the channel unit, where the compandor was replaced by a limiter-noise reducer combination, the out-of-band signaling circuits were simplified, and 2W/4W terminations and loop-converting relays were added. The successfully completed design provided a high-quality low-cost system.

CP61-1071 — **The Application of Carrier Systems to Exchange Trunk Plant in Canada.** *A. Curran, T. G. Fellows* — The demand for relatively long exchange

trunk circuits has created a need for a carrier system suitable for this specialized function. A basic requirement for such a system is that it may be operated over existing exchange trunk cables. This paper discusses the results of tests to determine the range of attenuation, crosstalk coupling loss, and anticipated noise on existing cables. It also shows how the observed values were used in designing the NXI Exchange Trunk Carrier System.

61-1073(III) — **The Leakage Reactance of a Ring-Type Transformer.** *P. P. Yeh* — The ring-type transformer, considered impractical for power transformation because of difficulty in construction and insulation, can now be built easily. Performance characteristics of this transformer are inherently better than those of the equivalent conventional unit. A formula is derived to calculate the leakage reactance of a ring-type transformer. Calculation can best be carried out by a small-scale digital computer, such as a Royal McBee LGP-30.

61-1074(III) — **Reactance and Kilowatt Losses of Multicircuit Transformers.** *M. W. Waterman* — Impedance losses, real and reactive, in multicircuit transformers can be calculated easily and quickly by using equations which are direct as well as general. Because the direct method saves time and reduces the chances of error, it is preferable to more laborious methods such as the use of equivalent circuits.

CP61-1075 — **Semiconductor Rectifier Overload Ratings.** *J. S. Read, E. E. Von Zastrow* — Previously, the rating of semiconductor rectifier cell current overloads of a recurrent nature has been difficult to handle with a high degree of confidence. A method is presented for determining these ratings by use of an extension of the general transient thermal resistance approach. By this means the cell junction–heat sink system thermal response to overload currents may be determined. Hence realistic values of overload current can be established which neither affect rectifier cell reliability nor cause excessive cell capacity to be designed into rectifier equipments.

61-1081(II) — **Self-Adaptive Systems with Variable-Parameter PID Controller.** *Y. Kaya, S. Yamamura* — A new type of the self-adaptive system has been developed. In this system parameters of the PID controller are so selected that the controller may compensate the process dynamics, which is measured automatically and continuously. Thus, in case the process dynamics changes in an unexpected way, the total system dynamics is always near the ideal one.

61-1082 — **Shading Coil Magnet of New Design.** *J. H. Kubiak, L. H. Matthias* — A new, reliable, analytical method for the design of shading coil magnets is described. In these magnets with equal shaded and unshaded pole-face areas, the fluxes of the shaded and unshaded poles are made equal in magnitude with substantially sinusoidal time variation. The phase angle between the two fluxes can be made to exceed 80 degrees so that the minimum of the variable holding force is more than 70 per cent of its maximum value.

CP61-1085. — **Tower Design Loadings and Broken Wire Assumptions.** *N. J. McMurtrie* — The conventional tower design loadings are expressed in a form suitable for application to what are now considered relatively small conductors. Direct application of these design loadings to transmission lines with large single conductors or bundled conductors is often impractical or unrealistic. This paper presents a critical appraisal of the form in which tower design loadings are specified and suggests some changes in approach which will make them more useful and realistic for the designer.

CP61-1087 — **Shaft Multiplication Precision Angle Encoder.** *D. A. Brouillette* — This discussion outlines a method of precision-angle encoding utilizing a magnetic multipole resolver for electrical shaft angle multiplication. Shaft position to digital conversion is accomplished by high resolution encoders attached to the vernier shaft. Such a system is capable of 2^{18} or 360,000 quanta of output for one revolution of the shaft to be measured. Accuracy is achieved by a unique combination of electric and mechanical networks. Systems with standard deviations of 5 seconds of arc have been delivered.

CP61-1088 — **Shock Hazard in Swimming Pools from Submerged 120-Volt Lighting.** *W. P. Taylor, R. J. Arthur, Sr.* — Complaints of electric shock in swimming pools with submerged 120-volt lighting resulted in an investigation to determine the causes and possible remedies. The authors have compiled technical data on the hazards of submerged 120-volt lighting and offer a remedy which involves effectively grounding all noncurrent-carrying metal parts of the wiring installation.

CP61-1091 — **The Direct Generation of Electric Power from a High-Velocity Gas Jet.** *D. J. Harris* — The possibility of generating electric power by the electromagnetic braking of a high-velocity gas jet is considered. The electrical characteristic of the gas is changed from an insulator to a poor but significant conductor which interacts directly with a magnetic field. The necessity of the turbine element in a conventional generating process is then removed, allowing an increase of working temperature and a subsequent increase in efficiency. The transfer of energy from the jet molecules to an electric circuit is particularly considered. Outstanding problems are assessed and suggestions are put forward for the solution of some of them, but the need for more fundamental research is emphasized.

CP61-1095 — **Special Transmission Tower Foundations.** *A. A. Ferlito, A. V. Price* — Some of the difficulties encountered in furnishing adequate line tower foundations for recent installations are described. These problems were the result of conditions and in some cases restrictions, at the locals selected for the particular line. Examples of the resulting special foundations are illustrated.

61-1096 (III) — **Modulation and Signal Selection for Digital Data Systems.** *Robert M. Lerner* — The statistical decision model of a communication channel is used to discuss a variety of signal modulation techniques intended to overcome the problems met in the use of voice-bandwidth channels for high performance digital data transmission. The equivalence of various modulation schemes to selection from an alphabet of signal waveforms is outlined. In the presence of additive white Gaussian noise, the performance of such simple-waveform systems as a-m, phase reversal, and FSK is the same to within a few db. The implications of the fact that the channel noise is not Gaussian, but impulsive in character, are briefly explored.

61-1097 (I) — **Binary Codes for Error Control.** *W. W. Peterson* — The model of a communication channel used in the study of binary codes, its relation to real data transmission channels, and assumptions about noise, are reviewed. Several error-correcting codes are listed with a brief description of their error-correcting capabilities and feasibility of their implementation. The most promising class of codes for implementation at the present are cyclic codes. The burst-error correcting cyclic codes are especially attractive from the point of view of implementation and a simplified block diagram for implementing a practical example of such a code is shown and discussed.

CP61-1098 — **Survey on the Use of Butyl Rubber Insulated Cable.** *L. D. Cronin, R. E. Hoy, and J. E. Johnson* — A survey was made among users to obtain information on their experience with butyl rubber insulated cable. Seventy-five questionnaires were returned from industry and 111 from utilities. These returns disclosed 45 industrial and 87 utility users with a total of 55 million conductor feet in service, 92 per cent of this by utilities. Data, covering a period of 15 years, show quantities in use and service reliability by type of industry and voltage.

CP61-1099 — **Selection of Single and Bundle Conductors and Accessories for Acceptable Radio Noise Performance.** *L. O. Barthold, H. E. House, J. Kaminski, J. J. LaForest* — The major factors entailed in the choice of line configuration and accessories for acceptable radio noise performance are reviewed. Calculation of the radio noise field by means of the generation and propagation characteristics of the transmission line is discussed. The conductor, conductor accessories, and insulators can be selected to have satisfactory radio noise performance on EHV lines. Achievement of tolerable radio noise levels depends upon a close examination of the many different variables.

61-1013 (III) — **The Polyphase Induction Motor with Solid Rotor Effects of Saturation and Finite Length.** *G. Angst* — An expression for the equivalent impedance of a solid rotor induction motor is derived, which includes the effects of saturation and finite length. The former effect is allowed for by the assumption of a rectangular magnetization curve, while the latter is given in the form of an end effect factor, obtained from the solution of a 3-dimensional field problem. Tests made on experimental motors with and without heavy copper end rings showed good correlation with calculated results.

CP-1030 — **Application of General Equations of Induced Voltage and Armature Reaction—Part I, Performance of an Induction Machine.** *H. H. Hwang* — The speed of an induction, or asynchronous, machine differs from synchronous speed by the slip, which depends upon the load. Conversion of electric to mechanical energy is here accomplished by induction only; the induction machine's performance is not very different from that of other types of a-c machines. As an alternative to theories now used in the analysis of induction machines, this paper develops the complete analysis from general equations of armature reaction, torque, and induced voltage.

61-1048 — **A New Method of Space Exploration by Radar Using Incoherent Scattering.** *T. Laaspere* — Incoherent scattering is discussed in the context of the phenomenon of scattering of radio waves by spatial fluctuations in electron density. A review is given of both the theoretical and the experimental results. Emphasis is placed on the ideas involved in measuring properties of the upper ionosphere, such as the electron density, temperature, electron drifts, and the strength and direction of the magnetic field.

61-1060 — **Analog Simulation of Digital Computer Programs.** *Robert Saucedo, T. W. Sze*—The objective of this paper is to reduce the concept of a digital computer program to an analogous sampled-data control system, which can then be studied and analyzed by established theories and simulated on an analog computer. In this connection, the convergence and the rate of convergence of various programs are established by observing the stability and the transient response respectively on an analog computer.

CP61-1064 — **Standard Performance Tests for Data Modems.** *R. M. Lerner* — Reproducible laboratory tests indicate performance under field conditions. Tests with additive white Gaussian noise are not typical of field conditions. Simulation of impulse noise now depends on recorded noise tapes with which reproducible testing procedures may be specified. Tests are also suggested on sensitivity of a modem to phase crawl, transient effects of dropout, and gross dependence of modem performance on the transmitted data format.

CP61-1066 — **Transistorized 2X24 Channel Carrier Telegraph Equipment.** *K. Takahashi, T. Kishigami, T. Matsuzaki, K. Sakurai* — The transistorized 2X24 channel carrier telegraph equipment consists of a pair of 24-channel FM type equipment in a bay recommended by the CCITT. Considering the weakness of transistor circuit and center frequency variation of the FM system caused by temperature rise, the parts and circuits are specially designed, for instance, to the use of AFC, electronic relay, special circuits of oscillator and discriminator.

CP61-1067 — **Analogue for Canned Motor Temperature Analysis.** *G. W. Penney, C. L. Thomson* — A passive network of resistors is used to represent the heat flow in a canned motor, since 1 volt represents 100 C rise and since the current representing losses is supplied from a 100-volt circuit. The increase in resistance with temperature is represented by a change in the heat conduction constant. Ordinary rheostats can be used as resistance since any adjustable resistance element can be switched into a common circuit for adjustment.

61-1068 (III) — **Single Phase Two-Valued Capacitor Motor Relay Selection.** *D. L. Trower, C. Evert* — The problems presented by an undesirably steep speed vs. phase winding voltage curve for a single phase capacitor start, capacitor run induction motor are discussed. A method of calculating the voltage across the phase winding as a function of speed is given along with a brief flow diagram for a digital computer program for calculating this voltage. Experimental and calculated curves are given. Emphasis is placed on methods of correcting an undesirable speed phase winding voltage relationship.

CP61-1083—**The Anchorage of Transmission Tower Foundations.** *M. Markowsky, N. J. McMurtrie* — The applications of commercial earth anchors to provide uplift strength in transmission tower foundations is described. The results of field tests demonstrate that tower foundations can be anchored satisfactorily and economically by the use of expansion-type anchors backfilled with power-tamped crushed stone. Preloading to the design capacity of each anchor will effectively eliminate initial creep and will ensure reliable high-capacity anchorage, with acceptable limitation on uplift movement.

CP61-1084 — **A New Approach to the Evaluation and Interpretation of Describing Functions.** *Y. H. Ku, C. F. Chen*—A new method is given for determining the describing function of the nonlinear input-output characteristic. A circle of radius A is constructed to represent a sinusoidal input $A \sin \theta$. An output contour is then constructed to represent the irregular output waveshape. The ratio of the area of the output contour to the area of the circle gives the describing function exactly. This method offers a bridge connecting the frequency domain and time domain analysis of nonlinear systems.

CP61-1093 — **Field Experience With a Wire Spring Crossbar Concentrator.** *R. P. Ebisch, J. S. Belcher* — The need for line concentration is established, the technique defined, and historical development that led to choice of a remote power supply and an ideal crossbar switch is traced. Mechanical and circuit details of the Gfeller-Leich unit are given. Future trends are forecast, with stress on carrier-concentrator combinations. Suggestions are made for proper application, emphasizing the need for adequate planning to obtain maximum economic savings through use of this new tool.

CP61-1105 — **Development of Structure and Anchor Designs for Guyed V-Type Towers.** *E. S. Zobel* — Guyed V-type towers for use on transmission lines are relatively new, and this paper deals with problems peculiar to their design, and offers solutions. It covers primarily guy slopes, guy anchor rods, guy anchors, center foundations and use of maintenance free materials. Structure and anchor testing show that this new design can be made to be equivalent in strength to conventional waist-type towers.

CP61-1108 — **High Strength Steels for Tower Design.** *S. A. Wilson* — High-strength steel has found an increasing use in the design of transmission towers. The type of steel used depends on the attributes desired; for example, whether high strength steel alone, or weldability, or corrosion resistance is the important factor. The recent conception of the use of nongalvanized corrosion resistant A-242 is discussed. Greater use of high-strength steel is indicated as the power industry expands.

61-1112 (I) — **Digital Tropospheric Scatter.** *J. R. Poppe, A. J. Vadasz*— An old communications tool is put to new use by combining it with new concepts in propagation. Using simple, proved binary detection methods—such as frequency shift keying—substantial range improvement is shown over multi-channel FM or SSB tropospheric scatter schemes, at the sacrifice of analog capability. Alternatively, over shorter distances, substantial reduction in equipment complexity can be achieved over other modes. Measurements made on a feasibility circuit of 150 miles using very simple equipment has shown the practicality of this concept.

CP61-1115 — **Active Doppler Acquisition Systems.** *C. H. Dawson* — Active (vehicle-borne transmitter) Doppler acquisition (no assumptions about the vehicle path are required) systems are treated from a mathematical standpoint. It is shown that solutions exist only when the number of receivers exceeds three and that linear solutions for the ranges are possible for certain systems including that system which uses five readings at each of five stations.

Order preprints from:
AIEE Order Department
345 E. 47 Street
New York 17, N. Y.

POWER FROM NICAD

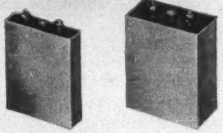
NICKEL CADMIUM RECHARGEABLE BATTERIES

FOR AIRCRAFT ■ MISSILES ■ CONSUMER PRODUCTS ■ ELECTRONICS ■ COMMUNICATIONS

3 TYPES HERMETICALLY SEALED CELLS

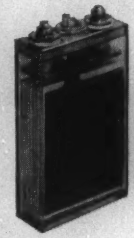
BUTTON 20-500 mAh

CYLINDRICAL 100 mAh-4.0 Ah



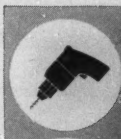
RECTANGULAR 1.5-2.3 Ah

2 TYPES VENTED CELLS

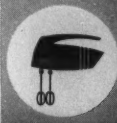


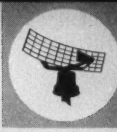
SINTERED PLATE 500 mAh-240 Ah (Miniaturized and Large Industrial Types)

POCKET PLATE 10 Ah-2048 Ah



CONSUMER PRODUCTS
- Cordless Appliances
- Dictating, Recording Equipment
- Shavers
- Radios
- Hearing Aids
- Electronic Medical Aids





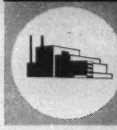
ELECTRONICS
- Instruments
- Receivers/Transmitters
- Computers
- Telemetering
- Portable Communications Equipment

MISSILES AND ROCKETS
- Control
- Guidance
- Telemetering

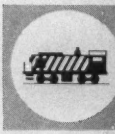
AIRCRAFT
- Engine Starting
- Emergency Lighting
- Controls and Alarms
- Rescue Gear

COMMUNICATIONS
- Telephone
- Telemetering
- Microwave

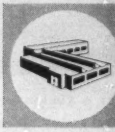
TYPICAL USES



POWER PLANTS
- Switchgear Operation
- Supervisory Control
- Emergency Lighting and Power
- Microwave



RAILROADS
- Switchgear Operation
- Microwave
- Engine Starting
- Lanterns



INDUSTRIAL
- Switchgear Operation
- Emergency Lighting
- Engine Starting
- Flashlights and Lanterns
- Cordless Power Tools

MARINE
- Engine Starting
- Radio and Alarms
- Life Boats

NICAD Batteries, in miniaturized Sealed and Vented Cells, are constantly in demand where there is a vital need for highly reliable and durable power sources. Suitable for the most stringent military requirements, these versatile cells are also adaptable to a wide variety of critical commercial, consumer and industrial applications.

Rechargeable, miniaturized, lightweight, NICAD Sealed Cells require no maintenance and operate in any position. High current discharge capabilities and extended shelf life make these cells ideal for battery-powered equipment that must operate instantly and efficiently.

NICAD sintered plate Vented Cells are designed to give exceptionally long life under cycle and float service. They can be stored in any state of charge for long periods without attention or fear of deterioration. They will operate in any position on discharge.

Pocket plate types are ideally suited for standby power and control, signal and alarm systems, emergency lighting, stationary engine cranking, cycling service, switchgear tripping and closing, locomotive starting. They seldom require maintenance, have an exceptionally long life and will maintain sustained voltage at heavy discharge rates. There's no sulphation, no corrosive fumes.

For further information on both Vented and Hermetically Sealed Cells, additional usage and application, write . . .

GOULD-NATIONAL GN BATTERIES, INC.

NICAD BATTERY DIVISION

GOULD-NATIONAL

BATTERIES, INC.

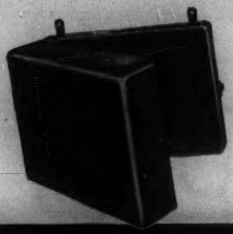
E-1406 1st National Bank Bldg.

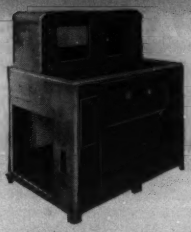
St. Paul 1, Minnesota

NICAD is a trademark of Gould-National Batteries, Inc.

CUBICLES • HOUSINGS • CABINETS

any size...





any quantity

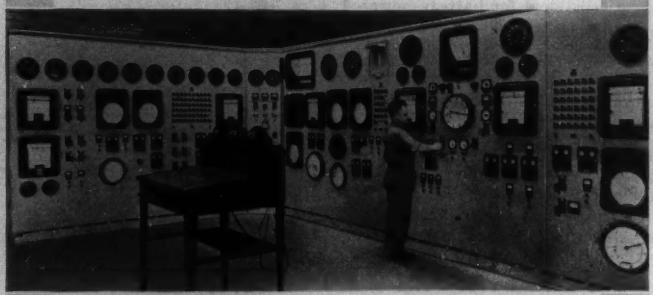
CONTROL PANELS & DESKS

KIRK AND BLUM

CUSTOM BUILT
ELECTRICAL ENCLOSURES

One unit . . . hundreds . . . or thousands, in any shape or size. KIRK & BLUM has the men, equipment and experience to fabricate sheet metal enclosures to exacting specifications. Put our 45 years of experience to work for you in building custom parts and assemblies of sheet steel, light plate, stainless, aluminum, monel and other alloys in gauges to ⅜".

Write today for your copy of the latest KIRK & BLUM Electrical Enclosures Catalog. For prompt quotation, send your prints to The KIRK & BLUM MFG. CO., 3204 Forrer Street, Cincinnati 9, Ohio.



Control Desks • Cubicles • Electrical Cabinets and Enclosures
Outdoor Electrical Enclosures • Instrument Panels • Control Panels
Transformer Tanks • Test Stands • Switch Gear Housings • Louvres

KIRK AND BLUM
METAL FABRICATION

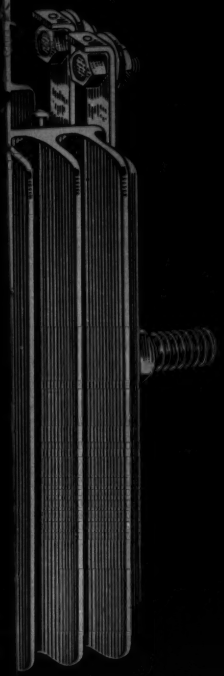
NEW/IMPROVED PRODUCTS

(Continued from page 8A)

delivers 30 ounce-inches of torque in either direction at 1 rpm. The motor is available for operation on 115-volt, 50- or 60-cps power supplies, and is offered in 150 different output speeds ranging from 300 rpm to 1/6 rph. *A. W. Haydon Co., Waterbury, Conn.*

New Materials in the News . . .

Better heat transfer ability at high temperatures, better flowability at low temperatures, and a 300 F flash point are features announced for a new transformer/circuit-breaker oil. Improved refining techniques permit the high flash point without disturbing the 58 SUS/100F viscosity. *Sun Oil Co., 1600 Walnut St., Philadelphia, Pa.* . . . Two new flexible, room-temperature-cured epoxy compounds to protect motor stator windings against moisture, dirt, abrasion, impact, chemicals, and other contaminants are available. Both Motor Casting Compound 10-063 and Motor Butter 10-062 handle the shock typical in motor operations. *Hysol Corp., Olean, N. Y.* . . . Scotchcast electrical resin no. XR-5046 is a room-temperature curing, semiflexible epoxy resin system specially formulated for sealing grounded well junction boxes and explosion-proof fittings. In large masses, the resin cures from the inside out, preventing stresses from pulling the resin away from the walls of the potted object. *Minnesota Mining & Mfg. Co., Dept. W1-369, 900 Bush Ave., St. Paul 6, Minn.* . . . A new magnet material has been developed which produces a nominal energy product of 7,500,000 gauss-oersteds, the highest magnetic power yet obtained commercially with alloys of Alnico composition. The new material known as Alnicus makes possible considerable reduction in the size of magnets. *U. S. Magnet & Alloy Corp., 266 Glenwood Ave., Bloomfield, N. J.* . . . Economy grade H-9758 silicone plate was developed for general applications requiring class H insulation. The material has excellent electrical properties and high impact strength and costs about 20 per cent less than standard grades. *Westinghouse Electric Corp., Micarta Div., Hampton, S. C.* . . . Excellent physical strength and corrosion resistance in addition to complete static draining are features claimed for a new static-electricity draining molding compound of fiber glass reinforced polyester. *The Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio.* . . . New ferrimagnetic materials have been developed for wide application in the microwave field. It is predicted that the materials will greatly facilitate fabrication of more sophisticated microwave components. *Sperry Microwave Electronics Co., Clearwater, Fla.*



Replaces Bridge Assemblies

in 50% less space, 30% less cost

WHERE TO USE THE POWER POINT

- on clutches, computers, for cathodic protection
- business machines, and burglar alarms, and battery chargers
- on magnetic chucks and amplifiers and magnetic reactors
- on motors and brakes and to close circuit breakers
- in circuits with telephones, telegraph and other equipment, such as
- vibrators and relays and traffic control
- power supplies for autos and airplanes and electro-plating
- *in short: almost anywhere you need d-c power close to the Point of use*

***SYNTRON CERTIFIED SEMICONDUCTORS**

All Syntron semiconductors have been tested and inspected to AQL level of 1.0, Inspection Level II, and are so certified. Electrical and mechanical tests include:

- Inspection to the appropriate JEDEC outline drawing.
- Stated PRV for specific current ratings over a range of diode or cell temperatures.
- Forward drop at rated current and a diode or cell temperature of 25°C.
- Testing of all rectifier assemblies at rated load conditions.

We guarantee that our semiconductors will meet their certified AQL performance levels for up to 18 months after manufacture provided they are not misused or misapplied. All Syntron semiconductors found to be defective in materials or workmanship will be replaced at no charge upon return to our plant.

SYNTRON

certified SEMICONDUCTORS

SYNTRON CO., Semiconductor Div., Homer City, Pa.

☐ Please send me more information on Syntron Power Point.
☐ Please have a Syntron representative call.

name _____ title _____

company _____

address _____

city _____ state _____

PRODUCT LITERATURE

Temperature Transmitter . . .

Bulletin 13-17C describes in 12 pages the type 12A pneumatic temperature transmitter. The brochure not only gives features of the transmitter design but also illustrates how the transmitter can be installed and adjusted to suit a wide range of application requirements. Also included are detailed specifications, descriptions of the operating principle, table of temperature ranges, and data on related accessories. *The Foxboro Co., Foxboro, Mass.*

Tailored Cable Assemblies . . .

Facilities of this manufacturer for assembling conductors into tailored cable with neoprene or polyvinyl chloride jackets are described in a new 4-page brochure. The booklet also explains the firm's capabilities in producing molded cable, as well as its ability to do design, development, and manufacturing of electromechanical equipment. *Electro-Mechanics, Inc., 160 Whiting St., New Britain, Conn.*

Control Cables . . .

Complete data on multiconductor electric cables used in control circuits are given in a 30-page catalog. The first section of the book describes Bronco 66 certified 600-volt line. The remainder covers certified shielded control cables and station control cables. *Western Insulated Wire Co., E. 30th St. at Santa Fe., Los Angeles, Calif.*

Terminal Blocks . . .

Complete specifications on a new modular terminal panel wiring block are contained in a 4-page folder now available. Also discussed are the advantages of the connectors over similar units of other designs as well as complete dimensional and test data. *AMP, Inc., Eisenhower Blvd., Harrisburg, Pa.*

Liquid Detection System . . .

Technical bulletin 2650 describes a universal liquid detection system. The 4-page brochure includes information on versatility, reliability, operation, and safety aspects of the system as well as detailed specifications. *Trans-Sonics, Inc., P. O. Box 328, Lexington, Mass.*

Slip Rings . . .

Latest types of slip rings, brush assemblies, rotary switches, and commutators in this manufacturer's line are described in an 18-page catalog. Also described are the manufacturing facilities of the manufacturer. *Slip Ring Co. of America, 3612 W. Jefferson Blvd., Los Angeles 16, Calif.*

Power Fuses . . .

Applications and selection of high-voltage power fuses are treated in a new 16-page booklet, 36-660, now offered. The publication is a comprehensive guide for selecting the power fuse best suited to various applications such as transformer and motor protection. Refill, drop-out, and current-limiting power fuses are discussed. Other information is presented on the interrupting ability, continuous current ratings, and melting characteristics of the fuses. *Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.*

Analytical Instruments . . .

Specifications and operating data on seven key instruments for research and production control are now obtainable. Electron probe microanalyzers, automatic X-ray spectrographs, 100-kv constant-potential X-ray spectrographs, portable X-ray spectrometers, standard vacuum X-ray spectrographs, X-ray diffractometers, X-ray diffraction units, and cameras are described. Applications are cited in the fields of atomic energy, chemicals, electronics, medicine, petroleum, and others. *Philips Electronic Instruments, Div. of Philips Electronics & Pharmaceutical Industries Corp., 750 S. Fulton Ave., Mt. Vernon, N. Y.*

Electronic Tracer . . .

Form 55-043 describes an electronic tracer used to guide oxygen shape-cutting machines from simple pencil-line sketches. The 4-page booklet illustrates how a built-in kerf compensator makes it possible to reproduce one or thousands of complicated metal parts easily. *Linde Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17, N. Y.*

Conduit and Fittings . . .

Graphic and factual information on bituminized fiber pipe, conduit, and fittings is given in a new 8-page catalog. Applications in electrical and telephone work are described, as well as applications in other fields. *Brown Co., Bermico Div., Berlin, N. H.*

Pressure Transducer . . .

The model 206 Teledyne bonded strain-gage pressure transducer is described in an 8-page brochure. Bulletin P-61206 emphasizes the features making the transducer in its three versions particularly suited to measurement of pressures encountered in high-speed chemical reactions as well as rocket, jet, and turbine engine tests. Specifications, prices, and ordering information are also included. *Taber Instrument Corp., 107 Goundry St., N. Tonawanda, N. Y.*

Electric Induction Furnaces . . .

This 12-page bulletin contains charts, illustrations, and descriptions of a full line of heavy-duty Tagliaferri 60-cycle induction melting and receiving furnaces. The furnaces use a controlled stirring action to produce homogeneous, fine-grained metal of high strength and ductility. *Hevi-Duty Electric Co., 304 Hart St. Watertown, Wis.*

Tubular Accessories . . .

"Advanced Design Tubular Accessories for Overhead Conductors" is the title of a new 40-page booklet. Featured in the publication are suggested installation methods, explanatory sketches, and tables listing dimensions, weight, and filler compound requirements. A full range of accessories is covered, including dead ends, joints, connectors, repair sleeves, and tee taps. *Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.*

Armored Cable . . .

A complete listing of fittings and accessories for interlocked armored cable is contained in a new 4-page bulletin (F11-135). Complete specifications and illustrations of the various components are given. *Thomas & Betts Co., 36 Butler St., Elizabeth, N. J.*

Squirrel-Cage Motors . . .

Bulletin 500 describes a line of integral horsepower (1 through 5 hp) polyphase squirrel-cage motors. The 2-page bulletin contains typical performance curves and NEMA frame assignments by horsepowers and speeds. *Leland Ohio Electric Co., 1501 Webster St., Dayton 1, Ohio.*

Wound Rotor Motors . . .

Bulletin 104 of four pages describes a new wound rotor motor available in sizes from 1 to 30 hp. Construction features, dimensions, and other specifications are included. *Louis Allis Co., Dept. P, 427 E. Stewart St., Milwaukee 1, Wis.*

Industrial Lubricants . . .

Characteristics and purposes of more than 60 different kinds of industrial lubricants are outlined in a 16-page brochure just made available. In addition, the booklet describes an industrial lubrication counseling service available to customers at no extra cost. *Pure Oil Co., 200 E. Golf Rd., Palatine, Ill.*

Gas Regulators . . .

Regulators for the accurate control of industrial gases in all applications are described in a 40-page catalog just made

(Continued on page 32A)

Exclusive Lapp Process Stabilizes Power Factor and Loss in Post Insulators

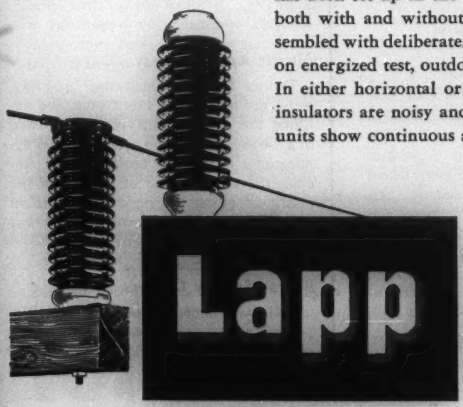
A LAPP LABORATORY REPORT

THE PROBLEM: Line Post and Station Post insulators occasionally have been found to show variation in power factor, charging current and watts loss under Doble tests. Field service seems not to have been impaired, but the phenomenon has been noticeable in such instances as erratic readings secured in tests of bushings connected to Post insulators.

THE FINDING: Some years ago engineers of the Lapp Laboratory staff were assigned the job of tracing down the cause of such variations. It was located and identified as contamination deposits on the inside walls of the insulators. Porcelain bodies for Lapp Post insulators are subjected to a severe test for electrical soundness—a 3-minute flash-over from the inside of the head around the body to the outside of the head. During this test the hole in the insulator fills with corona, and contaminating particles deposit on the walls of the hole; amount of this deposit and its effect on electrical characteristics vary with atmospheric conditions at the time of the test and at the time of plugging the hole for assembly.

THE SOLUTION: A thin coating of silicone applied to the wall of the insulator hole negates the effect of the corona contamination, and results in insulators dependably uniform in power factor, charging current and watts loss. Permanent effectiveness of the silicone coating is assured by its inherent chemical stability, and by the fact that the hole to which it is applied is sealed by the Lapp plug against weather, light, heat, or other physical or electrical attack. A Lapp patent is pending on the process.

THE VERIFICATION: All Lapp Line Post and Station Post insulator production for more than three years has incorporated the silicone treatment. The low initial power factor of the insulator has been maintained on every unit re-tested after service. In addition, in an effort to determine limits of effectiveness of the process, a series of insulators has been set up in the Lapp laboratory. Post insulators, both with and without the silicone treatment, were assembled with deliberately-defective plugs. They have been on energized test, outdoors, continuously for three years. In either horizontal or vertical mounting, all untreated insulators are noisy and show high loss. Silicone-treated units show continuous and unchanging low loss.



THE CONCLUSION: To the widely-known advantages, in electrical and physical performance, of its Post insulators, Lapp research has added the characteristic of stability in power factor, charging current and watts loss. *At Lapp, insulator design and production is a matter of continuous development and improvement.*

Lapp Insulator Co., Inc., Le Roy, N. Y.

Perhaps you've been doing as well as you'd expected—*up to now*. But, if you're apprehensive about the future—if you've wished your assignments were more stimulating—your work more rewarding—you owe it to yourself to investigate the opportunities at Motorola.

Here you will be encouraged to use *all* of your creative talents. You'll work on projects that spark vision, that inspire imagination. Because Motorola is an "engineer's company" you'll be working with respected men who can contribute to your growth—men who are quick to recognize and advance skill. You'll be working for a *secure*, diversified company not wholly dependent on one single market.

There are dozens of fine opportunities covering a wide range of fields of interest—just a few of which are listed below.

Write today. We'll send you a complete description of "Your Life at Motorola"—in Chicago; Phoenix; Riverside, California; Culver City, California; Minneapolis, Minnesota. Naturally your request will be kept in complete confidence.

- Radar transmitters and receivers
- Radar circuit design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstrom, traveling wave tube and backward wave oscillator
- Display and storage devices

2-WAY RADIO COMMUNICATIONS
- VHF & UHF receiver
- Transmitter design and development
- Power supply
- Systems engineering
- Antenna design
- Selective signaling
- Transistor applications
- Crystal engineering
- Sales engineering

- Design of VHF & UHF FM communications in portable or subminiature development
- Microwave field engineers
- Transistor switching circuit design
- Logic circuit design
- T.V. circuit design engineering
- Home radio design
- New product design
- Auto radio design
- Mechanical engineering
- Semi-conductor device development
- Semi-conductor application work

MR. W. H. HAUSMANN
Engineering Personnel Mgr. Dept. A
4545 Augusta Blvd., Chicago 51, Ill.

All qualified applicants will receive consideration for employment without regard for race, creed, color, or national origin.

MOTOROLA inc.

PRODUCT LITERATURE

(Continued from page 26A)

available. Quick-reference charts are given which indicate the range and variety of regulators obtainable from this manufacturer. A cross-referenced illustrated layout, in which all regulators are classified according to use, provides a convenient way of finding information in the catalog, Form ADC 705G. Information on accessory equipment is also included. *Air Reduction Sales Co., Div. of Air Reduction Co., Inc., 150 E. 42nd St., New York 17, N. Y.*

Circuit Breakers . . .

Advantages of 5-cycle type OZ distribution oil circuit breakers for 14.4- and 23-kv service are described in a new bulletin just announced. Exclusive construction features normally found only in transmission breakers are illustrated. A reference table of general dimensions and ratings is also included in 8-page bulletin 71B9705. *Allis-Chalmers, Milwaukee 1, Wis.*

A-C Capacitors . . .

An up-to-date version of the motor-run motor-start capacitor catalog is now available. This 16-page brochure features complete listings of this firm's expanded air-conditioner and refrigeration lines of a-c capacitors. Catalog MS61-10 includes important information covering capacities and physical dimensions as well as four pages of helpful engineering data. *Aerovox Corp., New Bedford, Mass.*

Elapsed Time Meter . . .

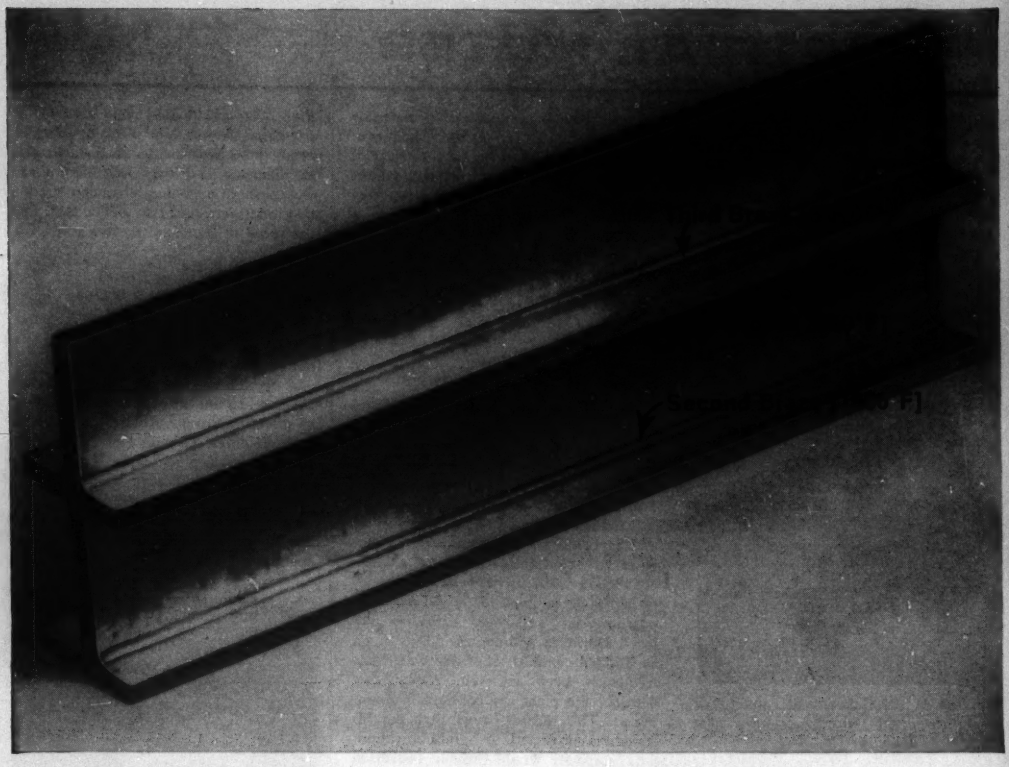
Bulletin GEZ-3354 of four pages describes the latest addition to a line of panel instruments—the type 236 elapsed time meter. Information relative to applications, features, specifications, standard ratings, and schematic diagrams are included. *General Electric Co., Schenectady 5, N. Y.*

Plastic Applications . . .

Design factors, dimensional stability, resistance to solvents, fabricating, and finishing are a few of the topics discussed in a 24-page booklet on properties and applications of Delrin acetal plastic. Included is a description of the use of the plastic in gears, bearings, and electrical appliances. *Cadillac Plastic & Chemical Co., 15111 2nd Ave., Detroit 3, Mich.*

Power Supply Centers . . .

Four-page bulletin no. 2469 describes 3-phase power supply centers for various applications. *McGraw-Edison Co., Pennsylvania Transformer Div., Box 330, Canonsburg, Pa.*



MONEL Alloy 404 . . . a new nonmagnetic alloy that can be multiple brazed in wet hydrogen

During multiple brazing operations, furnace atmospheres must contain enough water vapor to prevent the brazing alloy from wetting the fixtures. Yet the parts to be brazed must remain wettable to insure free flow, even after two or three trips through the furnace.

MONEL* Alloy 404 is a nickel-copper composition in which residual elements are held to low levels, to provide a clean, wettable surface to the brazing alloy even after continued exposure to wet hydrogen. And it retains the basic properties of MONEL Alloy 400 . . . low vapor pressure, strength, ductility, corrosion resistance.

Brazed three times in wet hydrogen — The test assembly above illustrates the excellent brazing properties of MONEL Alloy 404. It was built up in three slow passes through the furnace using hydrogen with a dew point of +70°F. On the third pass, the brazing alloy still flowed the full length of the joint.

The low magnetic permeability of MONEL Alloy 404 is not significantly affected by processing and fabrication, making it particularly suited for electronic parts. In any commercial form, size, or temper the permeability will not exceed a value of 1.1 at 27°F when measured using a field strength of 0.5 oersted. A nominal or typical value is about 1.01 at 27°F. (1.004 at room temperature using a field strength of 200 oersteds).

The thermal expansion of MONEL Alloy 404 is about the same as that of MONEL Alloy 400, and is sufficiently close to that of many other alloys frequently used in the construction of radio tubes to permit the firing of composite metal structures with a negligible amount of distortion. MONEL Alloy 404 also retains much of its strength at "out-gassing" temperatures.

For more information about this new alloy—write for our bulletin—Basic Data — MONEL Alloy 404. *Registered trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17 West Virginia

INCO

MONEL® Nickel-Copper Alloys

INDUSTRIAL NOTES

Delta Star Electric Opens New Transformer Plant

Production of distribution transformers, lightning arresters, and industrial crane conductor systems is under way in a new plant at Lynchburg, Va. Put into operation by Delta-Star Electric Div., H. K. Porter Co., the 250,000-square-foot plant will eventually employ more than 500 persons. Production facilities

Winding of aluminum strip coils for a new distribution transformer at a new plant in Lynchburg

include highly mechanized production equipment for distribution transformers; conveyorized production of lightning arresters, with automatic testing and recording of data for each arrester; improved and expanded facilities for industrial products; and an outdoor mechanical and electrical set-up for testing conductor systems under actual operating conditions.

Lehigh University Gets Western Electric Contract

The Institute of Research at Lehigh University is studying the measurement of resistivity of semiconductor materials under a contract from the Allentown, Pa., works of the Western Electric Co. The studies being conducted will take a broad look at semiconductor measurements. The results may culminate in a published work and in new design of test equipment. Both germanium and silicon materials are being studied under the contract which will terminate on July 1, 1962.

Sea Water Conversion Proved Economically Feasible

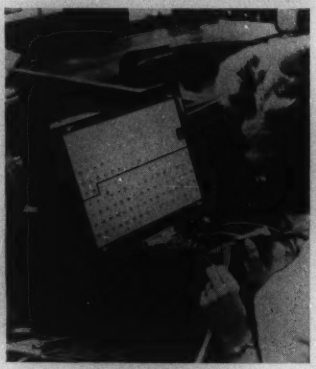
A 100,000-gallon-a-day sea water conversion plant at Southern California Edison's Mandalay Beach steam station is proving the feasibility of low-cost water conversion. The 26-stage long tube flash evaporator was designed and built by Aqua-Chem, Inc., of Waukesha, Wis., and is being used on an experimental basis to determine accurate sea water conversion costs. The system was installed in December, 1959, and has been operating at well over capacity ever since. During a 24-hour period, as much as 160,000 gallons of fresh water has frequently been achieved. Actual cost data for the plant are continually maintained. The records show that the installation, projected to a million-gallon-a-day capacity would provide converted water at less than $1.00 per thousand gallons.

Graphite Joined to Tungsten With Electron Beam Welding

Pyrolitic graphite has been joined to tungsten successfully with electron beam welding techniques by United Aircraft Corp.'s Hamilton Standard Div. Both pyrolitic graphite and tungsten are promising heat-resistant space-age materials. The technique has also been used to weld pieces of ceramics, such as alumina and titanium, to both molybdenum and tungsten. A high-power-density Hamilton-Zeiss machine is being used in the program. The machine pinpoints electron beams on a spot smaller than 0.010 inch in diameter and the electrons hit the workpiece in a vacuum chamber at 100,000 miles per second, or better than half the speed of sound.

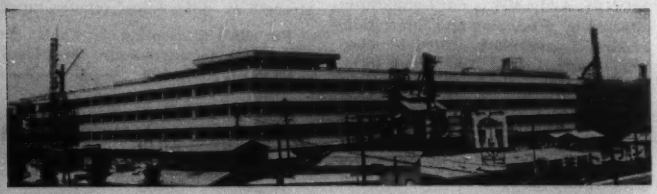
Test and Soldering Panel Facilitates Plug Manufacture

Winslow Product Engineering Corp. of Arcadia, Calif., has developed a unique panel designed to consolidate several operations into one simple, fast, and positive method of location in assembling of soldering groups of wires into various types of plugs. To wire a given plug, the operator uses a plug adapter, and a chart which matches the plug. Charts can be furnished to correspond with the plug by either letter or number configuration. The adapter and chart are inserted into position on the panel. The operator then



connects the plug to be wired to the plug adapter and begins to wire. When the soldering iron or probe touches a plug pin, the corresponding number, or letter, lights up on the chart. This indicates that the proper pin is being wired.

Asia's Largest Research Center Nears Completion



Scheduled for completion by the end of November is Tokyo Shibaura Electric Co.'s new research center in Kawasaki, Japan. The new facility is being built at a cost of $15,277,000, will cover 452,000 square feet, and will be staffed with 950 people. Toshiba—Japan's largest manufacturer of electronic and electrical equipment—is planning to invest over $333,000 for research purposes.

Trion Instruments Laser Yields Coherent Blue Beam

Four University of Michigan physicists have operated a Trion Instruments, Inc., laser to produce a coherent beam in the blue region. By focusing the laser's output beam (6,943 Angstroms) into a quartz crystal, the second harmonic (3,471.5 Angstroms) was detected. The second harmonic was produced by the high intensity of the laser beam at the focus, utilizing the nonlinear optical properties of quartz. Drs. Peter Franken, Wilbur Peters, and Gabriel Weinreich of

(Continued on page 41A)

INDUSTRIAL NOTES

(Continued from page 36A)

the University of Michigan physics faculty, and student Alan Hill, report their results in the issue of *Physical Review Letters* published August 15.

New Firm Will Build Low-Cost Computers

Digital computers for business and industrial applications selling for as low as $5,000 will be manufactured by Commercial Computers Inc., of Watertown, Mass. The newly formed company will concentrate on the development of low-cost, compact digital computers that will fill the wide gap between present desk calculators and the lowest-cost digital computers, which sell for approximately $30,000. The new computers will have all of the features of modern digital computing equipment, such as programming, storage, a variety of arithmetic functions, and adaptability to a wide number of input and output devices.

New Facilities in Brief . . .

Assembling and testing operations for lightweight aviation equipment are consolidated in a new 124,000-square-foot addition to the Cedar Rapids Div. of Collins Radio Co. Construction costs were about $1,800,000. . . . Construction has started on a 40,000-square-foot addition to the Minneapolis-Honeywell's inertial guidance facility at St. Petersburg, Fla. The $500,000 addition is being built to meet increased engineering development and production efforts. . . . Two new modern plants in Indiana will house the Master Electric Div. of Reliance Electric & Engineering Co. A 210,000-square-foot building in Columbus, Ind., and a 160,000-square-foot building in Madison, Ind., make up the new facilities. Both are aimed at improving productivity and speeding service to customers. . . . Preliminary work will commence shortly on construction of a $20 million petrochemical plant by Shawinigan Chemicals Ltd., and an associated $45 million 300,000-kw thermal electric station. The latter will be operated by The Shawinigan Water & Power Co., on the south shore of the St. Lawrence River near Montreal. The power company will also begin construction soon on its Des Coeurs hydroelectric development on the Upper St. Maurice River. . . . The Phelps Dodge Corp. has announced the signing of a contract to join other interests in the establishment of a major copper and brass fabricating company in Argentina. The project will involve an initial capital investment amounting to $11,900,000, of which the Phelps Dodge share will be $3.4 million.

Control and Instrumentation Engineers

A key research and development program is now underway at Atomics International to design long-life, compact, lightweight nuclear reactors that will provide auxiliary power systems for space applications. Many interesting problems exist to challenge electrical engineers who want to relate their present experience to reactor technology in any of the following areas:

FLIGHT INSTRUMENTATION DESIGN

Electrical control system design and/or aircraft or missile flight instrumentation design. Will establish flight instrumentation requirements, block diagrams for flight and test systems, preliminary specifications for each instrument or subsystem.

TELEMETRY

Responsible engineers to analyze, plan and specify the telemetry required to ascertain the performance of nuclear power plants during space tests. The individuals must have experience in missile instrumentation and telemetry of temperature, vibration, acceleration, etc. BS or MSEE preferred.

CONTROL ANALYSIS

Dynamic and control analysis including system start-up and full power operation. BS or MSEE plus familiarity with latest analog and digital techniques required.

CIRCUIT DESIGN

Electronics engineers experienced with both vacuum tube and magnetic devices to design and develop control circuits for compact nuclear power plants.

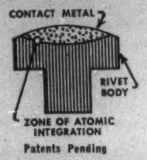
All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

For specific details write: Mr. E. K. Newton, Personnel Office, Atomics International, 8900 DeSoto Avenue, Canoga Park, California.

ATOMICS INTERNATIONAL
DIVISION OF NORTH AMERICAN AVIATION

Gibson Atomiclad* Electrical Contact Rivets now available in economical Gibson Assemblies

ATOMICLAD RIVETS ARE LOWER COST BECAUSE IT COSTS LESS TO MAKE THEM



Patents Pending

And they're BETTER because their bond of dispersed atoms of the precious contact metal and the base metal of the body is electrically and mechanically superior to other bonding methods. Cost is further reduced by limiting use of precious metal to electrical requirements of the contact.

Atomiclad Rivets are made in all standard forms and of copper, steel or other base metal with contact face of precious or semi-precious metals.

Many sizes and types are stocked in quantity. Write for Standard Stock List #2007, and for Technical Information Bulletin 400.

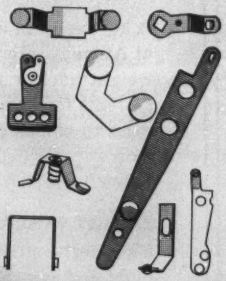
ECONOMICAL GIBSON CONTACT ASSEMBLIES

Gibson contact support manufacturing facilities include every phase—forming, riveting, heat-treatment and electroplating and comprises use of any specified metal.

When you specify Gibson Contact Assemblies, you get the benefit of years of engineering know-how in providing the best possible electrical union between contact and support member. Since all assemblies are Gibson-inspected, the customer suffers no loss through assembly rejects.

Gibson Engineers will design your complete contact assembly upon receipt of specifications. Or send your drawings for fabrication costs. If you prefer your own support member, send a sample for assembly cost.

*ATOMICLAD—Trademark Gibson Electric Company



GIBSON ELECTRIC SALES CORP.

BOX 588 DELMONT, PA.

BOSTON CHARLOTTE CHICAGO CLEVELAND DAYTON
DETROIT LOS ANGELES NEW YORK PHILADELPHIA PITTSBURGH
ROCHESTER ST. LOUIS SAN FRANCISCO SEATTLE

Gibsiloy ELECTRICAL CONTACTS Since 1929

Electrical Engineers

Opportunities for research and development in areas of semiconductors, plasmas, and ferromagnetic materials. Experience and/or advanced degree desirable. For further information write, briefly stating your background and experience, to

Mr. J. T. Jarman
Research Division
Allis-Chalmers Manufacturing Company
Milwaukee, Wisconsin

ENGINEERS

COMPUTER APPLICATION | **DISTRIBUTION ENGINEERING**

AEP

RELAY ENGINEERING | **SYSTEM PLANNING**

AMERICAN ELECTRIC POWER SERVICE CORP.

FORWARD LOOKING • INVESTOR OWNED • POWER SYSTEM

DISTRIBUTION ENGINEERING: Electrical Engineer, 5 to 10 years of field experience with utility power distribution systems. Responsibilities include economic analysis, overhead layout, construction and application of distribution equipment. Underground distribution experience desirable.

COMPUTER APPLICATIONS: Excellent career opportunity for an Electrical Engineer with power system experience to assume responsibility for development of IBM 704 & 7090 computer applications. Work in new section responsible for engineering, mathematical and program development on a company wide basis.

RELAY ENGINEER: Experienced engineer to plan, engineer & evaluate interconnected power network relay and automatic control systems. Responsibilities include working closely with system planning and other engineering specialists, system performance evaluation and advising customers on relay problems.

SYSTEM PLANNING: Electrical Engineer with 5-10 years experience in system planning to work on challenging problems in the area of power system analysis, generation and transmission planning.

Salary open. Company ideally located in N.Y.C. for easy commuting to suburban areas.

All replies confidential. Send resume stating education, experience, salary desired to Herbert H. Cooke, American Electric Power Service Corp.

2 BROADWAY, NEW YORK 8, NEW YORK

ELECTRIC HEATING Conference

The papers of the third biennial conference, held in Toledo, Ohio, April 23-24, 1957, were directed primarily to users on a practical rather than a theoretical basis. The program began as a basic refresher course on the various types of electric heaters: resistance, direct resistance, radiant, induction, and dielectric. Full sessions followed with more advanced papers on each type of heater.

Publication T-96 is sponsored by the AIEE Committee on Electric Heating and the AIEE Toledo Section. The 126-page book consists of 18 papers. The price is $3.50. Send orders to:

Order Department

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

33 West 39th Street

New York 18, New York